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Front and Back Cover: View from 918 km of ice-choked Chesapeake Bay on February 1, 1977, as 20- to 30-kn westerly winds and minus 10°C temperatures gripped the region. Image is generated from multispectral scanner 0.6 to 0.7 micrometer wavelength data. Resolution at the surface is 80 m; coverage of given areas repeats on an 18-day cycle. LANDSAT data are available through NOAA's Environmental Data Service. See article on Chesapeake Bay Ice Conditions on page 137.

The Secretary of Commerce has determined that the publication of this periodical is necessary in the transaction of the public business required by law of this Department. Use of funds for printing this periodical approved by the Director of the Office of Management and Budget through June 30, 1980.

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Mariners Weather Log

CHESAPEAKE BAY ICE CONDITIONS, 1976-77

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January 1977, one of the coldest on record, brought such extensive ice conditions to the Chesapeake Bay (fig. 1) that most of its waterways from the Susquehanna River and the Chesapeake and Delaware Canal south to Hampton Roads froze over completely, making ship passage difficult for many consecutive days. Not only was this a cold winter in the Bay area, but it also will be remembered as one of the coldest winters on record over the entire eastern two-thirds of the Nation. In most winters, ice is little or no problem to navigation south of the Chesapeake Bay Bridge near Annapolis, Md., but this winter ice did become a serious problem in the Lower Bay and especially in its tributaries.

One of the first indications that ice was to become a problem to navigation in the Bay occurred shortly after midnight on New Year's Day when the Coast Guard received its first call for assistance. A tug with a tow had become locked in newly formed ice which had shifted out of the Susquehanna River into the Upper Bay. By 1000 the Coast Guard cutter CHINOOK was underway (fig. 2). This would be the first of 87 assists that the CHINOOK made to vessels, mainly tugs and barges. Along with the CHINOOK, the cutter APALACHEE was active in keeping lanes open and traffic moving between the Chesapeake and Delaware Canal and Baltimore Harbor. They began their ice operations on January 1 and continued until February 23. During this period, the CHINOOK was underway 47 days and the APALACHEE 44 days.

Formal ice reports were compiled by the Coast Guard from January 1 through February 27 for the Upper Bay and until February 22 for the Lower Bay. The first report on January 1 described the general ice conditions at 0100 January 1, 1977, as clear in the Chesapeake Bay and 1 to 6 in thick ice in the Chesapeake and Delaware Canal and in the Bay's tributaries. The heaviest concentration of compact ice, 4 to 6 in thick and 7/8 coverage, was noted between Welsh Point and Worton Point. On January 18, the day after the winter's coldest day, ice had reached 8/8 coverage and was 6 to 24 in thick over the Upper Bay and 6 to 12 in in most tributaries (fig. 3). South of the Bay Bridge, 7/8 coverage pack ice was reported, 4 to 6 in thick; the tributaries were 2 to 12 in thick with up to 8/8 coverage. The most severe conditions began on the 23d when 8/8 coverage compact ice ranged from 4 in to 4 ft with ridging in the Upper Bay (fig. 4).

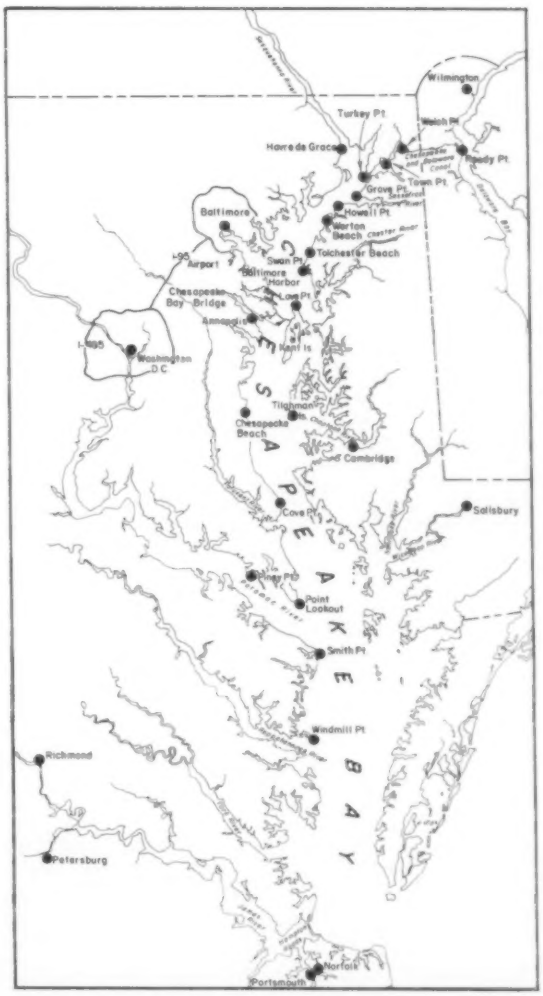

Figure 1.--Chart of Chesapeake Bay with reference points used in article.

Figure 2.--The U.S. Coast Guard cutter CHINOOK answered the first call for icebreaking assistance on New Year's Day. U.S. Coast Guard Photo.

The greatest concentration extended from Turkey Point to Howell Point. Passage north of Tolchester Beach had become extremely difficult. These severe ice conditions persisted until February 1, when a slight break in the coverage was noted in the Upper Bay. It was not until February 10, however, that the first real sign of a thaw was noted in the daily ice reports. At this time there was some shift from compact to open pack ice in the Bay and the mouths of the tributaries. On February 18, 8/8 coverage compact ice 12 to 24 in thick was still present in some locations. By the 20th, the Upper Bay began to show definite large breaks as reports indicated 6/8 coverage 1 to 18 in thick, and travel by convoy was encountering no difficulty. Above normal temperatures during the last week of February, especially the much above normal temperatures from the 23d through the 27th, brought an end to significant ice in all areas.

Coast Guard convoys began on January 2 when a westbound convoy formed at Reedy Point, Del., and

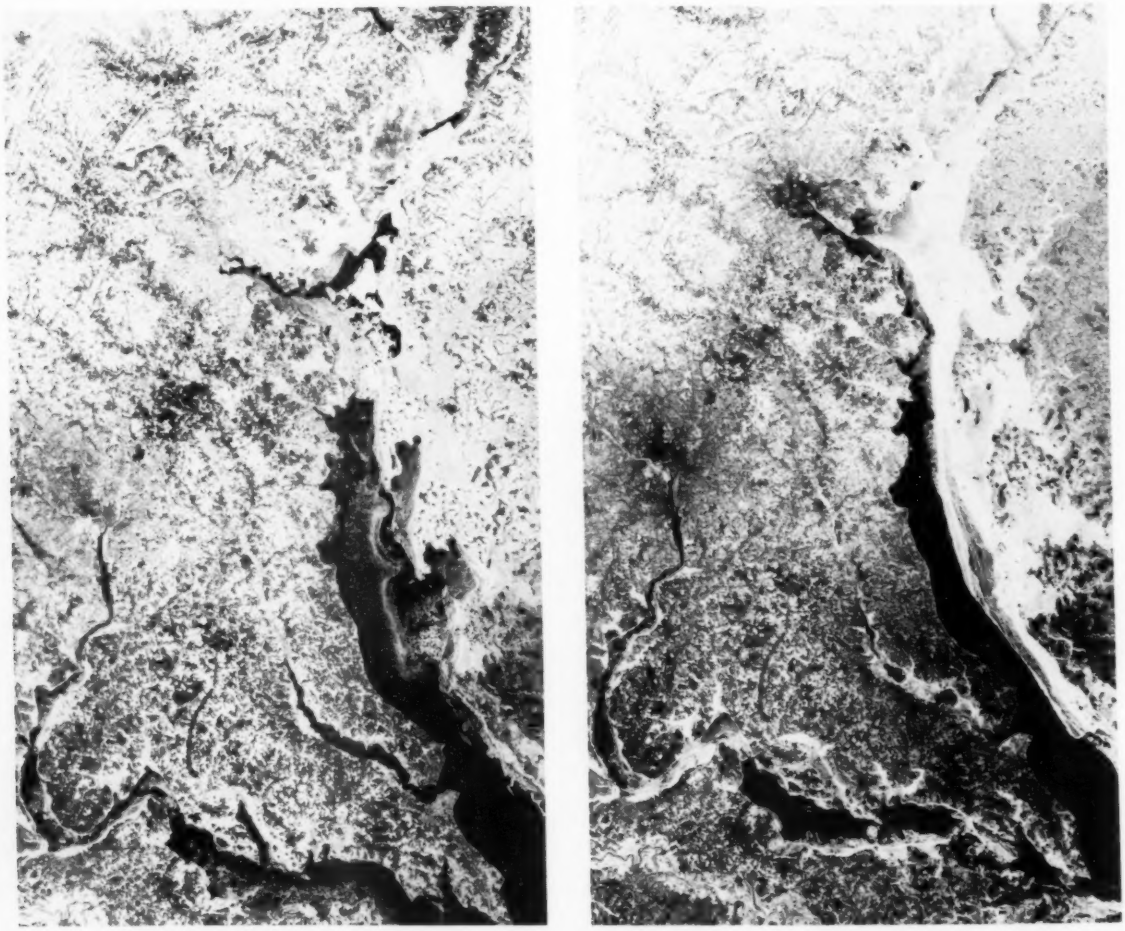

Figure 3.--LANDSAT photos of January 15, 1977 (left), and February 2, 1977 (right), vividly show the rapid buildup of ice in the upper Chesapeake Bay and along the Eastern Shore.

Figure 4.--A closeup view of rafted Bay ice.

proceeded through the Chesapeake and Delaware Canal to Baltimore. The first eastbound convoy from Baltimore formed in the vicinity of Brewerton Channel and departed for the Canal on January 3. Ice convoys in the Lower Bay commenced on the afternoon of January 15 (fig. 5). Most channels had become quite impassable for small vessels the previous day. At this time the Coast Guard cutter CHOCK (fig. 6) conducted a convoy up the Wicomico River to Salisbury, Md., bringing much needed fuel supplies. During the continuing ice period, the Coast Guard conducted many other convoys in the Lower Bay, especially up the following rivers: Potomac to Washington, D.C.; Wicomico; Nanticoke; Rappahannock to Fredericksburg; James; and the York. Icebreaking was also done in the Smith and Tangier Island areas. Among Coast Guard vessels involved in Lower Bay icebreaking duties were: Cutters CHOCK, CAPSTAN, and MOHICAN and buoy tenders RED CEDAR, RED BIRCH, and MADRONA. Vessels from other Coast Guard Districts were also employed in icebreaking duties on the Bay.

The Maryland Department of Natural Resources was also involved in icebreaking activities, being concerned mainly with the area just south of Bay Bridge. Vessels used were the ex-Coast Guard buoy tender J. MILLARD TAWES in the Crisfield and Smith Island-Tangier Island areas, the JOHN C. WIDENER in the Annapolis area, and the tug BIG LU in the Choptank area. The J. MILLARD TAWES sustained considerable damage to its hull and was sent to Portsmouth, Va., for repairs.

Ice was also a problem in Baltimore Harbor. The DRUM POINT, a private tug, was leased by the Maryland Port Administration for icebreaking in the Harbor and to supplement the Coast Guard's efforts to keep shipping lanes open to Baltimore Harbor from the Canal and the Annapolis Anchorage. The DRUM POINT was used from January 11 through February

Figure 5.--The 180-ft Coast Guard tender MADRONA leads a convoy of barges through Chesapeake Bay ice to Baltimore Harbor. U.S. Coast Guard Photo.

Figure 6.--The Coast Guard cutter CHOCK was kept busy this winter, leading convoys up the rivers of the Lower Bay. Many communities were in desperate need of fuel.

14. Only once before in the past 10 yr was it necessary for the Maryland Port Administration to lease an icebreaking tug and then only for 2 days.

For the first time since 1966, Maryland Pilots were unable to reach vessels at the Annapolis Anchorage where they awaited berth in Baltimore Harbor 20 mi away. The problem was solved by using helicopters to fly the Pilots to the ships. On January 17 there were four vessels--the CETRA LYRA, FORELAND, M.G. TSANGARIS, and IONIAN SKIPPER--at the Anchorage which Pilots reached by helicopter (fig. 7).

The Jamestown-Scotland Ferry, Virginia's only major ferry still in operation, was locked at its dock on the James River by heavy ice. This forced daily commuters to drive an extra 80-mi roundtrip to cross the River. The last time this occurred was in 1967 when the ferry was unable to operate for 19 days.

Records at the area's National Weather Service Offices reflected the winter's unusually cold weather. These records extended into the late 19th century. Offices at Wilmington, Del., and Norfolk, Va., located at opposite ends of the Bay, recorded their

Figure 7.--Rafted ice along the shipping channel blocks the view of a container ship's hull off Tolchester, Md. Photo courtesy of Chris Bothe, Kent County News.

Table 1.--Average temperature and departure from normal for National Weather Service Offices in the Chesapeake Bay area, January 1977

Office	Average monthly temperature (°F)	Departure from normal	Average daily temperatures January 16-23 coldest period (°F)	Departure from normal	Remarks
Wilmington, Del.	20.8	-11.2	15.3	-16.8	Coldest January since 1894
Baltimore, Md.	22.9	-10.5	18.1	-15.6	5th coldest January at City Office since 1871
Annapolis, Md.	24.0	-10.5	19.0		
Washington, D.C.	25.4	-10.2	21.1	-14.9	5th coldest January since 1871
Richmond, Va.	25.3	-12.2	19.0	-19.0	2d coldest January since 1898
Norfolk, Va.	29.3	-11.3	22.5	-18.3	Coldest for any month since 1871

coldest January. For Richmond, Va., it was the second coldest January; for Baltimore, Md., and Washington, D.C., it was the fifth coldest January. Table 1 gives a summary of temperature data for these stations and Annapolis, Md., and shows a departure of as much as 10° to 12°F below normal for January 1977. Also included is the average daily temperature for the coldest 8-day period and departure from normal. The temperatures were unusually cold for this area and are noteworthy for their duration.

Both October and November 1976 were unusually cold. December was also unusually cold at the beginning of the month, but from the 10th through the 20th, daily temperatures were normal or above. Daily temperatures began to drop below normal on December 21 and remained below normal for the most part until February 10. During this 52-day period, the Baltimore Weather Service Office recorded only 7 days when the average daily temperature equalled or exceeded 32°F. From February 10 on, daily temperatures were generally above normal except during the 15th through the 21st. It should be noted that the usual "January Thaw" did not occur this year.

This was the first season since 1971 that ice became a serious problem for navigation in the Bay (fig. 8). During the last decade, there were 4 consecutive years in which ice did become a problem, especially in the Upper Bay: January 1968, 1969, and 1970 and January-February 1971. Previous history indicates severe ice conditions in the Bay during the years 1847, 1856, 1874, 1875, 1881, 1886, 1893, 1899, 1904, 1917, 1918, 1923, 1934, 1935, 1936, 1940, 1959, and 1961. The winter of 1917-18 brought unprecedented ice conditions over the entire Bay and was, most likely, the most severe this century. It was similar to the present winter in that it was preceded by an unusually cold autumn and long in duration. Traffic on the Bay and its tributaries during the winter of 1917-18 came to a virtual halt. To assist the war effort of World War I, powerful battleships were required to open sea lanes into Baltimore Harbor. February 1936 is also remembered for its severe ice conditions over the entire Bay so late in the season. A brief history of ice conditions on the Bay is given in Howard H.

Figure 8.--Tug and barge get an assist from a Coast Guard icebreaker. The approaches to the Chesapeake Bay Bridge can be seen in the background.

Engelbrecht's article "Severe Ice Conditions on Chesapeake Bay During the Winter of 1960-61" (Mariners Weather Log, Vol. 4, No. 4, July 1961, pp. 112-116).

Damage caused by this year's ice in the Bay is estimated in the millions of dollars. Preliminary estimates from the Coast Guard on damage to a great number of navigation aids, including buoys and structures, are of the order of $1,250,000 (fig. 9). Damage to piers and waterside property was widespread. The economic loss for those whose livelihood depends on the Bay was also great. No deaths or serious injuries were reported.

ACKNOWLEDGMENTS

Appreciation is expressed to the many officers and men of the U.S. Coast Guard who provided ice reports and other useful information, the Maryland Department of Natural Resources, and the Maryland Port Administration.

Figure 9.--On January 28, the combined pressure of 12 in of ice and strong winds tilted the Sharp Island lighthouse off its foundations.

EASTERN NORTH PACIFIC TROPICAL CYCLONES, 1976

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Tropical cyclone activity over the eastern North Pacific in 1976 began June 1 and ended October 29. The number of tropical cyclones was about normal with eight hurricanes, six tropical storms, and four tropical depressions. Table 2 shows the monthly distribution of cyclone activity, and tables 3 and 4 compare this activity with past years. The 1966-76 period probably includes all tropical cyclone activity in the area due to satellite coverage during that time. Prior to 1966 some cyclone activity possibly could have gone undetected due to the sparsity of data. A summary of the important features of the 1976 eastern North Pacific tropical cyclone season is given in table 5. The season was exceptional in that one of the hurricanes, Kathleen, was the first such storm to hit southern California since 1939. Cyclone tracks are shown in figures 10 and 11.

Tropical cyclone advisories were issued by the Eastern Pacific Hurricane Center four times daily at 0300, 0900, 1500, and 2100. A total of 393 advisories was issued beginning with 1800 June 2 and ending with 1200 October 29.

Several reconnaissance flights were made by U.S. Air Force and NOAA aircraft into eastern Pacific tropical cyclone activity during the season. The first two flights, into hurricanes Annette on June 9 and Bonny on June 27, were made primarily in support of research by the National Hurricane and Experimental Meteorological Laboratory in Miami, Fla. The third flight on September 9 was into hurricane Kathleen off the west coast of Baja California. Four flights were made into hurricane Liza on September 28, 29, and 30, while the hurricane was south of the Baja California peninsula. Three flights were made into hurricane Madeline on October 6, 7, and 8, and two flights were made into tropical storm Naomi on October 28. While satellite imagery continues to improve and is probably one of the most important tools used by the tropical forecaster today, aircraft reconnaissance and Surface Synoptic Ship Reports retain their importance as invaluable comparative observations for both the tropical forecaster and satellite meteorologist.

The National Environmental Satellite Service, collocated with the Eastern Pacific Hurricane Center, provided excellent satellite coverage during the 1976 tropical cyclone season. Several movie loops were available each day as well as visual and infrared data at 30-min intervals from the stationary SMS-2 (Synchronous Meteorological Satellite) and polar-orbiting NOAA-5 satellites. Detail on the satellite pictures was excellent with full disk resolution at 4 mi and sector resolution at 2 mi with 1/2-mi resolution available on request. Especially useful were the H-curve "enhanced" pictures from infrared imagery depicting the upper level, cold-core centers of the tropical cyclones. Gridding of satellite pictures was accurate to within a few miles due to stability of the satellite (SMS-2) over the Equator and easily visible landmarks. Cyclone intensity was calculated using the Dvorak technique of satellite cyclone analysis (Mariners Weather Log, Vol. 19, No. 4).

Table 2.--Monthly distribution of Eastern Pacific tropical cyclones, 1976*

	May	June	July	Aug.	Sept.	Oct.	Nov.	Total
Tropical depressions	0	2	0	2	0	0	0	4
Tropical storms	0	0	3	2	0	1	0	6
Hurricanes	0	2	1	2	3	0	0	8
Total	0	4	4	6	3	1	0	18

*Cyclone ascribed to month in which it began.

Table 3.--Frequency of Eastern Pacific tropical storms and hurricanes combined by months and years*

Year	May	June	July	Aug.	Sept.	Oct.	Nov.	Total
1966	0	1	0	4	6	2	0	13
1967	0	3	4	4	3	3	0	17
1968	0	1	4	8	3	3	0	19
1969	0	0	3	2	4	1	0	10
1970	1	3	6	4	1	2	1	18
1971	1	1	7	4	2	2	1	18
1972	1	0	1	6	2	1	1	12
1973	0	3	4	1	3	1	0	12
1974	1	3	3	6	2	2	0	17
1975	0	2	4	5	3	1	1	16
1976	0	2	4	4	3	1	0	14
Total	4	19	40	48	32	19	4	166
Average	0.4	1.7	3.6	4.4	2.9	1.7	0.4	15.1

*Cyclone ascribed to month in which it began.

Table 4.--Number of Eastern Pacific tropical storms reaching hurricane intensity by months and years*

Year	May	June	July	Aug.	Sept.	Oct.	Nov.	Total
1966	0	1	0	4	2	0	0	7
1967	0	1	0	2	1	2	0	6
1968	0	0	0	3	2	1	0	6
1969	0	0	1	1	1	1	0	4
1970	1	0	1	1	0	1	0	4
1971	1	1	5	2	2	1	0	12
1972	1	0	0	6	1	0	0	8
1973	0	1	3	0	2	1	0	7
1974	0	2	2	4	2	1	0	11
1975	0	1	2	3	1	1	0	8
1976	0	2	1	2	3	0	0	8
Total	3	9	15	28	17	9	0	81
Average	0.3	0.8	1.4	2.5	1.5	0.8	0.0	7.4

*Cyclone ascribed to month in which it began.

While numerous merchant and fishing vessels passed close to tropical cyclone centers during the 1976 season and undoubtedly experienced heavy weather and seas, no reports of casualties or damage were received. However, some smaller craft were damaged in port when the last four cyclones of the season moved onshore along the Mexican coast.

Hurricane Kathleen moved onshore along the northern Baja California coast, then proceeded northward through the southern California desert area and into western Nevada. Kathleen was the first storm of

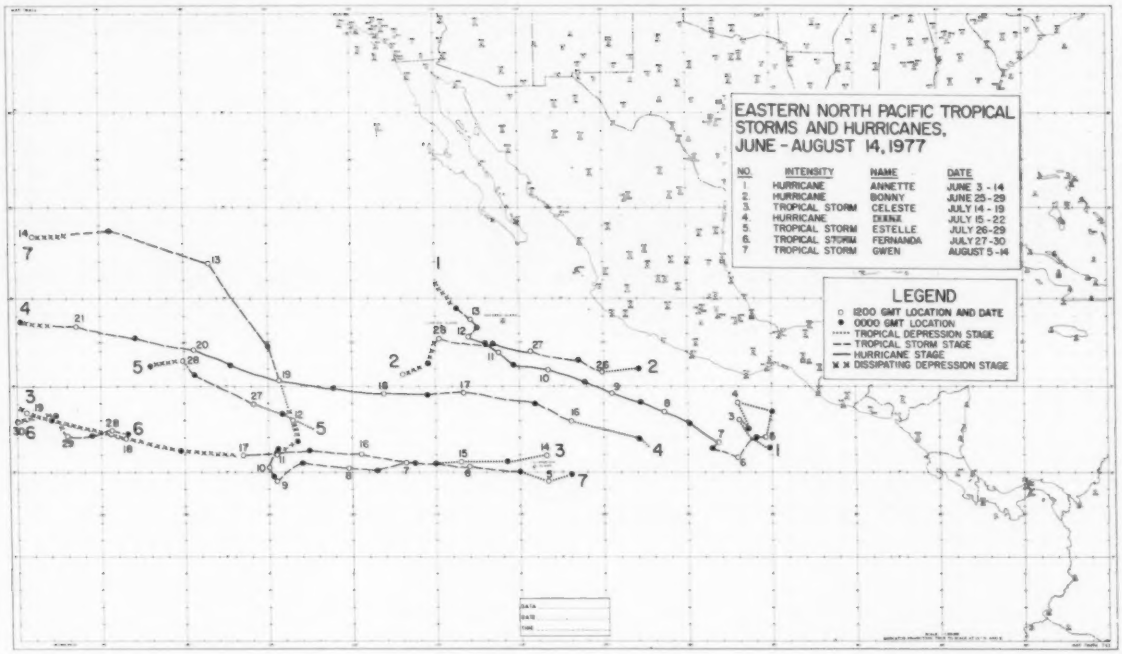


Figure 10.--Tracks of eastern North Pacific tropical storms and hurricanes, June - August 14, 1976.

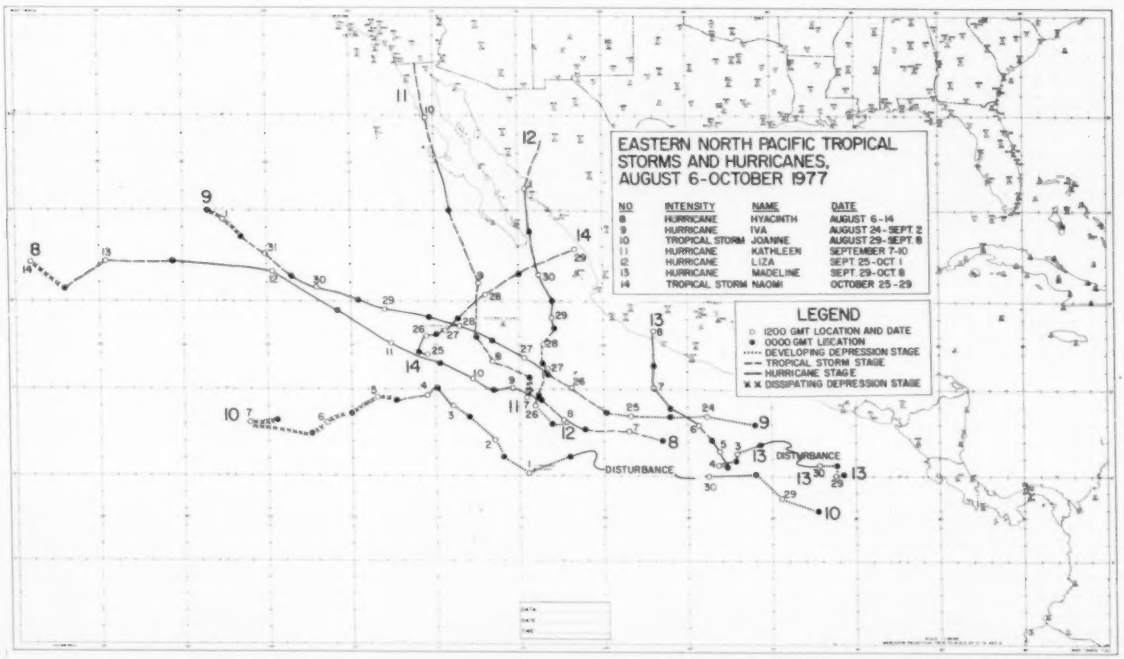


Figure 11.--Tracks of eastern North Pacific tropical storms and hurricanes, August 6 - October 1976.

Figure 12.--Kathleen's raging floodwaters poured through this canyon wiping out a bridge on U.S. Highway 80 and undermining Interstate 8. Photo courtesy of the San Diego Union.

tropical origin to move into southern California since 1939. It left an average of 3.5 in of rain over the barren desert areas and as much as 14.5 in in the higher mountains. Flash flooding took the lives of four people in California, and winds to 66 kn caused one death in southwestern Arizona. Kathleen caused over $160 million of damage over southern California and Arizona (figs. 12 and 13). No reports of casualties or damage were received from Mexico.

Liza was the second hurricane of the 1976 season to move onshore over Mexico. The hurricane skimmed by the southeastern tip of the Baja California peninsula, then headed north through the Gulf of California, and entered mainland Mexico 45 mi north of Los Mochis. Casualty and damage reports on the mainland were not received, but on the Baja peninsula the city of La Paz sustained considerable damage and loss of life. Heavy rains caused the failure of an earth-fill dam, and ensuing floodwaters left 435 dead.

Madeline, which had the strongest winds of any hurricane during the 1976 season, went inland along the Mexican coast 45 mi northwest of Zihuatanejo. Early evacuation is believed to have held casualties to a minimum. Damage was probably extensive, but no reports were received.

Tropical storm Naomi, the last of the season, went inland near Mazatlan on the Mexican coast and moved onshore with winds of only 35 kn. No reports of damage were received.

HURRICANE ANNETTE, June 3-14

The second tropical cyclone of the season began as a tropical disturbance at 1800 June 2 near 11°N, 95°W. Six hours later, the disturbance was upgraded to a tropical depression with winds of 25 kn at 11.4°N, 95.2°W. Satellite imagery indicated little change in the depression over the next 72 hr, with a loosely defined cyclonic circulation at night becoming better organized in the daylight hours. By 0600 June 6, winds increased to 40 kn near the center, and the depression was upgraded to tropical storm Annette near 12°N, 96°W. The RENALDER, 140 mi north of the storm's center at 1800 on June 6, reported easterly 35-kn winds and a pressure of 1007.7 mb. The storm moved westward at 5 kn and was upgraded to hurricane status at 0600 June 7 about 360 mi south of Acapulco, Mexico.

Figure 13.--Looking like an island, the remnants of Meyer Creek Bridge stand in the dry creek bed. Rampaging waters from Kathleen wrought havoc in California's Imperial Valley. Photo courtesy of Imperial Valley Press.

Winds had increased to 65 kn near the center with gusts to 85 kn. Satellite imagery indicated an eye beginning to form near the center by 1200 June 7. Annette continued to intensify and moved west-northwestward at 8 kn over 88°F water. On June 9, U.S. Air Force reconnaissance aircraft flew into Annette and located the center at 14.6°N, 105°W, at 1707. Surface winds were estimated at 90 kn, and minimum surface pressure computed at 925 mb. The aircraft also reported a well defined eye with a closed wall. The hurricane reached its maximum intensity of 120 kn with gusts to 140 kn at 1200 on June 10 near 16°N, 108.3°W, about 300 mi southwest of Manzanillo, Mexico. It continued westward for another 12 hr (fig. 14), then turned northwestward toward colder (78°F) water. Annette's eye was no longer visible on satellite pictures after 0600 on June 11 as the hurricane, under the influence of an upper-level trough of low pressure, moved northward over colder water. It was downgraded to a tropical storm with 60-kn winds at 1200 on the 12th near 17.8°N, 113°W. Weakening rapidly, Annette was downgraded to a tropical depression with 25-kn winds at 1800 on June 13 near 19.2°N, 113.2°W. Two more advisories were issued on the depression before convective activity near the center dissipated by 0600 on the 14th near 20.9°N, 115°W.

HURRICANE BONNY, June 25-29

Bonny began as a tropical disturbance over 86°F water near 12°N, 100°W, at 0600 on June 22. Moving

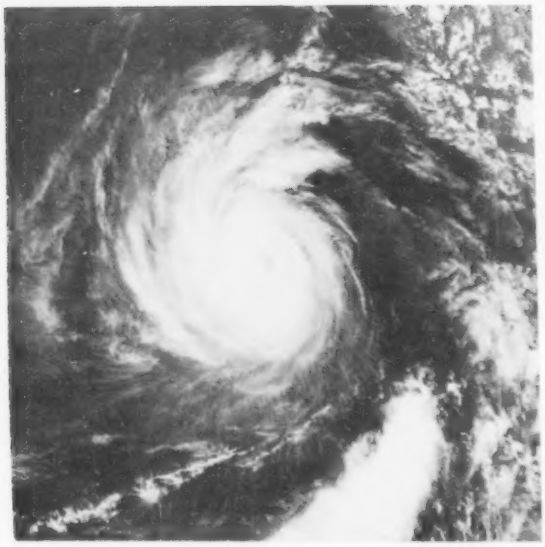


Figure 14.--Hurricane Annette near 16.1°N, 109.8°W, on June 10. Winds near the center were 115 kn with gusts to 130 kn.

northwestward, the disturbance was upgraded to a tropical depression with 30-kn winds at 1800 on the 25th near 16°N, 103°W, 200 mi west of Acapulco. The depression moved westward at 7 kn and was upgraded to a tropical storm near 15.8°N, 105.1°W, at 1200 on June 26. Winds near the center were estimated at 45 kn with gales extending out 75 mi. By 0000 on the 27th, winds had increased to 55 kn with gales extending out 90 mi from the center now at 16.5°N, 106.5°W. Bonny moved westward at 10 to 12 kn and was upgraded to a hurricane at 1200 near 17°N, 109.4°W, about 135 mi southeast of Socorro Island. Winds had increased to 65 kn with gusts to 75 kn near the center, and gale winds extended out 100 mi from the center. At 1800

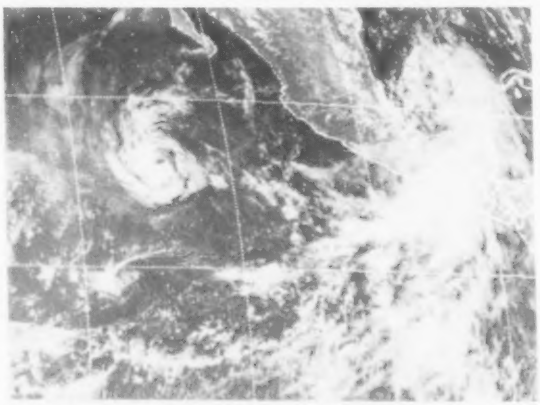


Figure 15.--Hurricane Bonny is dissipating near 16.1°N, 114.8°W, on June 28. Winds are 30 kn with gusts to 40 kn. Tropical cyclone Four is near 13.7°N, 95.8°W, with 25-kn winds.

Table 5.--Eastern North Pacific tropical cyclone statistics, 1976[1]

Cyclone name/ number	Lifespan		Date-time of classification/Location						Highest windspeed (kn)		
	From:	To:	Depression	Storm	Hurricane	Storm	Depression	Ended		From:	To:
Tropical cyclone One	June 2-3		021800 12.5, 113.0				030600 13.0, 116.0	030600 13.0, 116.0	30	021800 12.5, 113.0	030000 12.5, 113.0
Hurricane Annette	June 3-14		03000 11.4, 95.2	060600 12.0, 96.0	070600 10.8, 98.8	121200 17.8, 113.0	131800 19.2, 113.2	140600 20.9, 115.0	120	100000 15.2, 106.1	101800 16.1, 109.4
Hurricane Bonny	June 25-29		251800 16.0, 103.0	261200 15.8, 105.1	271200 17.0, 109.4	280000 17.3, 111.6	281200 17.7, 114.8	291800 16.2, 117.2	65	271200 17.0, 109.4	280000 17.3, 111.6
Tropical cyclone Four	June 28-30		281800 13.0, 96.0				300000 16.0, 95.5	300000 16.0, 95.5	30	290000 14.5, 95.3	300000 16.0, 95.5
Tropical storm Celeste	July 14-19		141200 11.0, 108.5	151800 10.8, 115.0			171200 11.0, 126.5	190600 13.5, 139.5	45	160000 10.5, 116.2	170600 11.0, 124.0
Hurricane Diana	July 15-22		151800 11.5, 102.5	161200 13.0, 107.0	171800 14.4, 114.3	201200 17.1, 129.4	211800 18.4, 138.0	220000 18.6, 139.8	85	181800 14.7, 119.8	190000 14.9, 121.1
Tropical storm Estelle	July 26-29		261800 12.5, 122.5	270600 14.0, 125.0			280600 16.2, 130.2	290000 16.2, 132.0	35	270600 14.0, 125.0	280600 16.2, 130.2
Tropical storm Fernanda	July 27-30		271800 12.4, 133.3	280600 11.9, 133.8			291800 13.0, 137.0	301200 13.0, 140.0	35	280600 11.9, 133.8	291800 13.0, 137.0
Tropical storm Gwen	August 5-14		050000 9.8, 107.0	060000 10.0, 110.0 121800 15.5, 124.0			111200 11.0, 124.5 140600 24.0, 136.2	 141200 23.5, 139.0	55 45	080000 10.1, 118.5 121800 15.5, 124.0	090000 10.5, 123.0 130600 19.8, 126.8
Hurricane Hyacinth	August 6-14		061800 12.1, 102.2	070600 12.0, 102.0	091200 15.0, 110.2	130000 22.0, 130.5	140000 20.5, 137.0	141200 22.0, 139.0	100	100600 15.1, 112.1	111200 17.5, 117.5
Tropical cyclone Eleven	August 7-8		071800 14.2, 134.0					081800 14.0, 134.6	25	071800 14.2, 134.0	081800 14.0, 134.6
Tropical cyclone Twelve	August 16-19		160000 15.5, 120.9				190000 15.0 132.0	190000 15.0, 132.0	30	160000 15.5, 120.9	180600 14.5, 129.0
Hurricane Iva	Aug. 24-Sept. 2		240000 13.0, 96.0	251800 13.5, 104.0	261800 15.2, 107.8	301200 20.7, 122.0	010000 23.4, 126.4	020000 24.9, 128.5	115	280600 18.2, 112.4	290000 19.0, 115.2
Tropical storm Joanne	Aug. 29-Sept. 8		290000 7.8, 92.2	031200 14.0, 114.0			050000 14.4, 117.3	080600 12.5, 124.5	40	031200 14.0, 114.0	041200 14.6, 115.6
Hurricane Kathleen	Sept. 7-10		070600 15.0, 109.0	080000 15.5, 109.3	100000 25.0, 114.0	100600 26.8, 114.4		101200 30.0, 115.5	70	100000 25.0, 114.0	100600 26.8, 114.4
Hurricane Liza	Sept. 25-Oct. 1		251800 13.0, 107.0	261800 14.0, 108.5	281800 18.0, 108.1	011800 28.8, 108.6		011800 28.8, 108.6	115	301800 22.2, 109.1	010600 25.2, 109.3
Hurricane Madeline	Sept. 29-Oct. 8			290000 10.0, 90.5 050000 10.5, 97.5	 061800 13.1, 109.3	 081200 18.2, 102.0	291200 10.0, 91.1	 081200 18.2, 102.0	35 125	290000 10.0, 90.5 060600 17.6, 102.1	291200 10.0, 91.1 081200 18.2, 102.0
Tropical storm Naomi	October 25-29		250600 16.8, 115.6	251800 16.8, 115.8				291200 22.8, 106.8	45	271800 18.6, 114.2	280000 18.9, 113.7

[1]All dates, times GMT; all latitudes north, all longitudes west.

the ANCUD, 40 mi north of Bonny and 70 mi south of Socorro Island, reported east-southeasterly 52-kn winds. NOAA reconnaissance aircraft flew through Bonny at 1939 June 27 and located the center at 17.2°N, 110.7°W, 90 mi south of Socorro Island. Surface winds were estimated at 63 kn, and the pressure was computed at 987.4 mb. Bonny weakened as she moved westerly over colder water (76°F) at about 10 to 12 kn. She was downgraded to a tropical storm near 17.2°N, 111.6°W, on June 28 at 0000 and then to a tropical depression with 30-kn winds at 1200 near 17.7°N, 114.8°W (fig. 15). The final advisory was issued at 1800 June 29 with the center near 16.2°N, 117.2°W.

TROPICAL STORM CELESTE, July 14-19

After 2 weeks of relative inactivity in the Tropics, the fifth cyclone of the season began as a tropical disturbance at 0600 July 14, 570 mi southwest of Acapulco, Mexico. Moving westward at 10 to 12 kn, the disturbance was upgraded to a tropical depression at 1200 near 11°N, 108.5°W. Continuing to the west at 12 to 15 kn, it was upgraded to tropical storm Celeste with 35-kn winds at 1800 July 15 near 10.8°N, 115°W. The WALTER RICE, 180 mi to the south, reported 25-kn southerly winds. Winds near the center increased to 45 kn by 0000 on the 16th and continued at 45 kn through

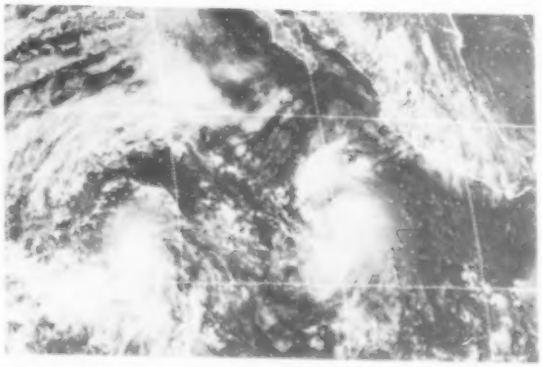


Figure 16.--Tropical storm Celeste is near 11.2°N, 122.4°W, at 2315 July 16 with 45-kn winds. Tropical storm Diana to the right near 13.9°N, 109.1°W, has 45-kn winds.

0000 July 17 (fig. 16). Moving westward, Celeste weakened and was downgraded to a tropical depression with 30-kn winds at 1200 near 11°N, 126.5°W. Accelerating to the west-northwest at 15 to 20 kn, the de-

pression began to move to colder water and weakened rapidly. The final advisory was issued on July 19 at 0600 when the cyclone dissipated into a large area of scattered showers and thundershowers near 13.5°N, 139.5°W.

HURRICANE DIANA, July 15-22

Diana began as a tropical disturbance near 10°N, 99°W, 400 mi south of Acapulco at 0600 July 15. The RACHEL, 75 mi to the west, reported intermittent, moderate rain and west-northwesterly 20-kn winds. At 1200 the NORSE VIKING, 140 mi northeast of the disturbance, reported east-southeasterly 35-kn winds in squalls. The disturbance was upgraded to a tropical depression at 1800 on the 15th near 11.5°N, 102.5°W. The RACHEL, now 90 mi to the south, continued to report intermittent, moderate rain, but the winds had decreased to 10 kn. The depression was upgraded to tropical storm Diana as it moved west-northwesterly over 85°F water at 1200 on the 16th near 13°N, 107°W. The winds were 35 kn. By 1800 winds near the center increased to 45 kn. The RACHEL reported 15-kn westerly winds 180 mi to the south. Satellite infrared and "enhanced" imagery showed Diana with a diameter of 200 mi and upper-level clouds extending out about 400 mi. By 1800 on the 17th, Diana had developed an eye, and winds near the center had increased to 65 kn. The storm was upgraded to hurricane status near 14.4°N, 114.3°W. Diana continued to intensify as she moved westward at 10 to 12 kn over 83°F water. At 1800 July 18 winds near the center, now at 14.7°N, 119.8°W, had increased to 85 kn with gusts to 95 kn (fig. 17). The hurricane continued on a westerly track at 12 to 15 kn and began to move over cooler water toward a large low-level cloud field. Weakening slowly, Diana was downgraded to a tropical storm with 55-kn winds at 1200 July 20 near 17.1°N, 129.4°W. Although infrared satellite imagery no longer showed Diana with an eye, visual pictures continued to show a weak remnant of the eye through 1800. Winds near the center diminished rapidly, and the storm was downgraded to a tropical depression with 30-kn winds at 1800 on the 21st near 18.4°N, 138°W. The last advisory was issued by the Eastern Pacific Hurricane Center at 0000 July 22 with the center near 18.6°N, 139.8°W. The cyclone continued westward into the Central Pacific Hurricane Center's forecast responsibility. That Center followed the depression through 1800.

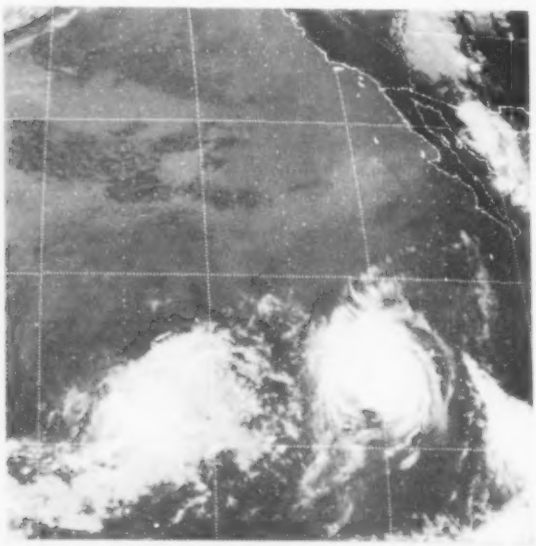


Figure 17.--Hurricane Diana at 1745 July 18 near 14.7°N, 119.8°W, as seen by infrared satellite imagery with 2-mi resolution. Winds were 85 kn with gusts to 95 kn near the center.

TROPICAL STORM ESTELLE, July 26-29

Tropical cyclone seven began as a tropical disturbance at 1800 on July 24 near 9°N, 113°W, 900 mi southwest of Acapulco. Moving west-northwestward at 12 kn over 82°F water, the disturbance began to show cyclonic circulation by 1800 on the 26th, and it was upgraded to a tropical depression near 12.5°N, 122.5°W. Satellite imagery at this time showed a large area of cyclonic circulation about 450 mi in diameter with two centers of convective activity--one near the center of the depression and the other 250 mi to the west. As the depression moved west-northwestward, the distance between the centers increased. At 0600 on July 27, the eastern depression was upgraded to tropical storm Estelle with 35-kn winds near the center at 14°N, 125°W. The western center of convective activity was now 450 mi west of the storm center. By 1200 the two centers were distinctly separate with the western center becoming tropical cyclone eight near 13°N, 132.9°W, and the eastern center tropical storm Estelle near 14°N, 125.8°W. Estelle continued west-northwestward and slowly weakened as tropical cyclone eight, moving west-southwestward, intensified. Estelle, moving into cooler water, was downgraded to a tropical depression with 30-kn winds at 0600 July 28 near 16.2°N, 130.2°W (fig. 18). The final advisory was issued at 0000 July 29 with the center near 16.2°N, 132°W.

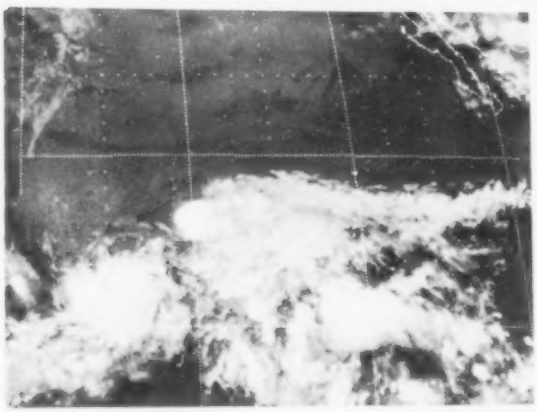


Figure 18.--Tropical storm Estelle at 0415 July 28 near 16°N, 130°W, is moving west-northwestward at 14 kn with 35-kn winds and weakening. Tropical depression Fernanda southwest of Estelle is near 12°N, 133.6°W, moving southwestward with 30-kn winds and intensifying.

TROPICAL STORM FERNANDA, July 27-30

Tropical cyclone eight, spinning off the north side of tropical storm Estelle, moved west-northwestward with Estelle before splitting off as a separate disturbance, centered near 13°N, 132.9°W, at 1200 July 27. This disturbance moved west-southwestward to become a tropical depression at 1800 near 12.4°N, 133.3°W. By 0600 July 28 winds near the center had increased to 35 kn, and the depression was upgraded to tropical storm Fernanda near 11.9°N, 133.8°W (fig. 18). Satellite imagery showed Fernanda with a small diameter of about 200 mi and no visible eye. As Fernanda turned westward, the remnants of Estelle, 250 mi north, turned southwestward and merged with Fernanda.

By 1800 on July 29 Fernanda began to weaken and was downgraded to a tropical depression with 30-kn winds at 13°N, 137°W. The WAKAHATA MARU, 300 mi to the west, reported northerly 20-kn winds in squalls. The WAKAHATA MARU, 60 mi south of the depression, reported southerly 20-kn winds on the 30th at 0600. The last advisory was issued by the Eastern Pacific Hurricane Center at 1200 with the center near 13°N, 140°W. The Central Pacific Hurricane Center at Honolulu, Hawaii, continued to follow the depression through 0600 on August 1 when it dissipated near 14°N, 149.9°W.

TROPICAL STORM GWEN, August 5-14

Gwen began as a tropical disturbance at 1800 on August 3 about 380 mi south of Acapulco, Mexico. Moving westward at 13 kn, the disturbance was upgraded to a tropical depression with 30-kn winds near 9.8°N, 107°W, at 0000 on the 5th. Within 24 hr winds had increased to 35 kn, and the depression was upgraded to tropical storm Gwen near 10°N, 110°W, at 0000 August 6. Winds increased steadily to 45 kn by 0600 and to 55 kn by 0000 August 8 (fig. 19). Gwen continued westward and passed over the northern edge of an area of cooler (80°F) water. The storm began to slow down and weaken. At the same time, tropical depression Eleven, 900 mi to the west, was dissipating rapidly, and tropical storm Hyacinth, 750 mi to the east, was moving westward and intensifying. At 1800 August 8 the SERGEY YESENTN, 200 mi south-southwest of Gwen, reported 30-kn southwesterly winds. As Gwen passed to the north of the SERGEY YESENTN, winds on the ship increased to 35 kn still out of the southwest. By 0600 on August 9, Gwen had become quasi-stationary near 11°N, 124°W. At 1200 on the 11th, the storm was downgraded to a tropical depression with 30-kn winds with the center still near 11°N, 124°W. Between 0600 and 1200 on August 12, the depression began to move again. Under the influence of hurricane Hyacinth 500 mi to the north, the depression accelerated northward at 25 kn and intensified rapidly. The depression was upgraded again to tropical storm Gwen with 45-kn winds at 1800 near 15.5°N, 124°W. The ATTICA, 30 mi east of Gwen, reported southerly 45-kn winds. By 1200 on the 13th, Gwen was at 22°N, 128.5°W, with 40-kn winds, while Hyacinth was weakening rapidly 330 mi to the west with 35-kn winds. The HOBART STAR, 215 mi north of Gwen at 1200 on August 13, reported easterly 25-kn winds. By 1800 the winds on the HOBART STAR, now 150 mi northeast of Gwen, had shifted to southeasterly at 25 kn. The COLUMBUS CAPRICORN was 140 mi west of Gwen with 30-kn northeasterly winds. Turning to the west, Gwen began to slowly weaken. She was downgraded to a tropical depression with 30-kn winds at 0600 August 14 near 24°N, 136.2°W. Hyacinth, 200 mi to the south, continued to weaken, then turned to the north and merged with the depression near 23.5°N, 139°W, at 1200. The depression continued to drift westward into the Central Pacific Hurricane Center's forecast area, becoming diffuse near Hawaii on the 17th.

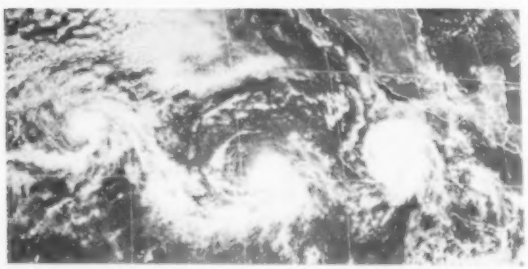


Figure 19. --Tropical cyclone Eleven (left) at 1815 August 7 is near 14.2°N, 134.1°W, with 25-kn winds, and tropical storm Hyacinth (right) is near 12.5°N, 105.2°W, moving westward at 11 kn with increasing 45-kn winds. Tropical storm Gwen (center) at 10.2°N, 118.1°W, is moving westward at 11 kn with increasing 45-kn winds.

HURRICANE HYACINTH, August 6-14

This storm began as a disturbed area near 9.5°N, 96.7°W, at 1800 August 5. Moving west-northwestward at 11 kn over 85°F water, the disturbance began to show signs of cyclonic circulation and was upgraded to a tropical depression at 1800 on the 6th. Satellite information showed the center near 11.5°N, 101°W. Winds increased to 35 kn by 0600 August 7, and the depression was upgraded to tropical storm Hyacinth near 12°N, 102°W. By 0000 on the 8th, winds near the center had increased to 55 kn. The MARITIME JUSTICE, 200 mi south-southeast of the center, reported southerly 25-kn winds and moderate, continuous rain. Winds near the center increased to 70 kn by 1200 on the 9th, and the storm was upgraded to a hurricane near 15°N, 110.2°W. By 1800 Hyacinth, with 85-kn winds near the center, had developed a small, well defined eye 10 mi in diameter near 14.7°N, 111°W. The MARITIME JUSTICE, 140 mi to the south, reported westerly 35-kn winds and heavy, continuous rain. At the same time ATTICA was 180 mi south of Hyacinth with westerly 35-kn winds, and the CAPE LEEUWIN, 220 mi east-northeast of the center, had southeasterly 25-kn winds. Moving west-northwestward at 6 kn, Hyacinth continued to intensify over 84°F water. Winds increased to 95 kn by 0000 August 10 with the center near 14.8°N, 111.4°W. The MARITIME JUSTICE, 160 mi to the southwest, reported violent rain showers and westerly 30-kn winds. Another ship, the KANAGAWA MARU, 300 mi east of the hurricane, reported southerly 25-kn winds. Socorro Island, 250 mi north of Hyacinth, reported easterly 35-kn winds in squalls. Hyacinth moved to 15.1°N, 112.1°W, by 0600, and winds near the center increased to 100 kn. The eye, which had developed only 12 hr earlier, was

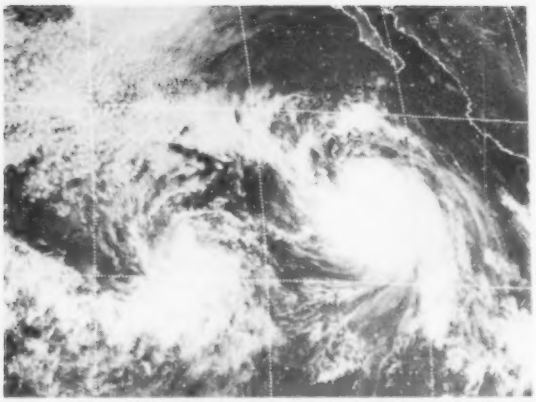


Figure 20.--At 1715 August 10 tropical storm Gwen is nearly stationary at 10.4°N, 124.6°W, with 40-kn winds. Hurricane Hyacinth is northeast of Gwen at 15.9°N, 113.7°W, moving west-northwestward at 10 kn with 100-kn winds and gusts to 115 kn.

no longer visible on satellite imagery. By 1800 (fig. 20) Hyacinth had moved to 16°N, 113.8°W. The KANAGAWA MARU reported southerly 25-kn winds and continuous light rain 270 mi to the east. The ATTICA, 250 mi south of the storm's center, reported southwesterly 35-kn winds. The NORDLAND, 220 mi north-northwest of Hyacinth, reported east-northeasterly 35-kn winds, and the CAPE LEEUWIN, 240 mi north-northeast of the center, reported east-northeasterly 25-kn winds and heavy, intermittent rain. Winds began to decrease near the center after 0600 August 11 as the hurricane accelerated west-northwestward at 15 to 20 kn, 500 mi northeast of nearly stationary tropical storm Gwen. By 1200 Hyacinth had moved to 17.5°N, 117.5°W; winds near the center had decreased to 85 kn. She continued west-northwesterly, accelerating to 25 kn by 1800 August 12 with the center near 22.2°N, 127.8°W. Winds had decreased to 70 kn as the hurricane moved over cooler water (74°F) and continued to weaken. As Hyacinth passed to the north, tropical storm Gwen began to intensify and moved northward, eventually passing 330 mi to the east of Hyacinth at 1200 on the 13th. Hyacinth, turning westward, was downgraded to a tropical storm with 55-kn winds near 22°N, 130.5°W, at 0000 August 13. The storm turned southwestward at 1200 and was downgraded to a tropical depression with 30-kn winds near 20.5°N, 137°W, at 0000 on the 14th. At 0600 the depression had moved to 20°N, 139°W; it then turned northward and merged with Gwen, now a tropical depression, near 23.5°N, 139°W, at 1200. The last advisory was issued by the Eastern Pacific Hurricane Center at 1200 August 14 with the center near 22°N, 139°W. Gwen continued to drift westward into the Central Pacific Hurricane Center's forecast area, carrying with it the remnants of hurricane Hyacinth.

HURRICANE IVA, August 24 - September 2

Iva began as a tropical disturbance near 13°N, 94°W, 420 mi southeast of Acapulco, Mexico, at 1800 August 23. She moved westward at 12 kn over 83°F water with warmer (85°F) water to the north and east and intensified rapidly. Satellite pictures showed an area of intense thunderstorm activity 300 mi in diameter. By 0000 on the 24th, cyclonic circulation appeared about the center on satellite time-lapse movie loops, and the disturbance was upgraded to a tropical depression near 13°N, 96°W. Winds increased to 35 kn by 1800 August 25, and the depression was upgraded to tropical storm Iva near 13.5°N, 104°W, 320 mi southwest of Acapulco. Turning west-northwestward and moving at 10 kn, Iva continued to intensify, drawing warm, moist air northward from the Intertropical Convergence Zone 400 mi to the south. By 1600 on the 26th, NOAA-5 high-resolution satellite imagery showed Iva with a small eye approximately 10 mi in diameter. Winds near the center increased to 65 kn by 1800, and the storm was upgraded to a hurricane near 15.2°N, 107.8°W, 300 mi southwest of Manzanillo, Mexico. Continuing west-northwestward, Iva passed 70 mi south of Socorro Island at 0000 August 28. Winds near the center of the hurricane had increased to 110 kn, and winds on Socorro Island were easterly at 55 kn. By 0600 the hurricane's eye had increased to 25 mi in diameter, and winds near the center had increased to 115 kn (fig 21). Socorro Island, now 85 mi to the east, reported southeasterly 45-kn winds. By 1200 winds on the Island had decreased to 25 kn with Iva now 140 mi to the west. As Iva continued on a west-northwesterly track, the hurricane began to move over cooler (80°F) water and slowly weaken. By 0900 August 29 the eye was no longer visible on satellite imagery. Winds continued to decrease as the hurricane moved west-northwestward at 9 kn into an extensive field of low stratus and stratocumulus clouds. By 1200 August 30, Iva was moving over 76°F water, winds near the center had decreased to 60 kn, and the hurricane was downgraded to a tropical storm near 20.7°N, 122°W. Iva

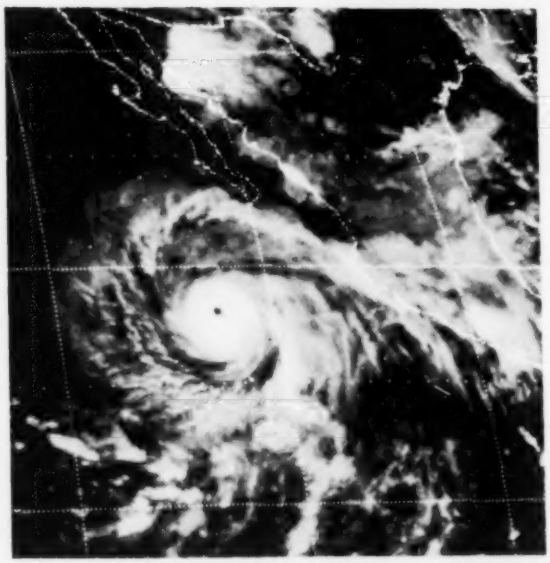


Figure 21.--Hurricane Iva at 0615 August 28 is near 18.2°N, 112.4°W, moving west-northwestward at 10 kn with 115-kn winds.

continued to weaken rapidly as it moved northwestward into the field of low clouds and over still colder (70 to 74°F) water. By 0000 September 1, the storm was downgraded to a tropical depression near 23.4°N, 126.4°W. The final advisory was issued by the Eastern Pacific Hurricane Center at 0000 on September 2 with the center of the depression dissipating rapidly near 24.9°N, 128.5°W.

TROPICAL STORM JOANNE, August 29 - September 8

The fourteenth tropical cyclone of the season began as a tropical disturbance at 1200 August 26 near 4°N, 80°W, about 150 mi west of the Colombian coast. The disturbance, centered in a large area of convective thunderstorm activity 300 mi in diameter, moved northwestward at 15 to 18 kn to 8.5°N, 84.5°W, 45 mi west of the De Osa Peninsula on the coast of Costa Rica by 1200 August 27. Turning west-southwestward and moving at 18 kn away from the coast, the center of the disturbance moved to 6.5°N, 87.5°W, by 0000 on the 28th. It then turned westward, slowed to 12 to 14 kn, and began to intensify. By 0000 August 29, satellite pictures indicated definite circulation about the center, and the disturbance was upgraded to a tropical depression with 25-kn winds near 7.8°N, 92.2°W. The storm turned toward the west-northwest and moved at 11 kn over 81°F water. Winds increased to 30 kn by 0000 August 30, with the center near 9.9°N, 96°W. The depression then turned westward and, moving at 10 kn, began to weaken. By 1800 satellite imagery indicated that circulation had ceased about the center, and the depression was downgraded to a tropical disturbance again near 9.5°N, 99°W. It then moved rapidly west-northwestward at 18 kn and appeared to be dissipating into an area of widely scattered thunderstorm activity 300 to 400 mi in diameter. However, between 0600 and 1200 on August 31, the thunderstorm activity increased again and coalesced into a solid area 300 mi in diameter. Within 12 hr satellite imagery indicated cyclonic circulation about the center of the activity, and the disturbance was upgraded to a tropical depression again at 0000 September 1 near 11°N, 107°W. The MORILLO, 80 mi northeast of the center, reported east-southeasterly 30-kn winds and violent rain showers. Turning west-southwestward, the depression moved to 10°N, 110°W, by 1800, then turned northwestward and, moving at 8 kn over 82°F water, began to intensify. By 1200 September 3, winds near the center had increased to 40 kn, and the depression was upgraded to tropical storm Joanne near 14°N, 114°W. Joanne moved toward the northwest to 15°N, 114.9°W, by 0000 on the 4th, then turned west-southwestward, and began to slowly weaken (fig. 22). Low clouds pushing down from the north continued to weaken the storm to the extent that it was downgraded to a tropical depression with 30-kn winds near 14.4°N, 117.3°W, by September 5 at 0000. Turning back toward the west and continuing to weaken, the depression moved to 12.5°N, 124.5°W, where the final advisory was issued on September 8 at 0600.

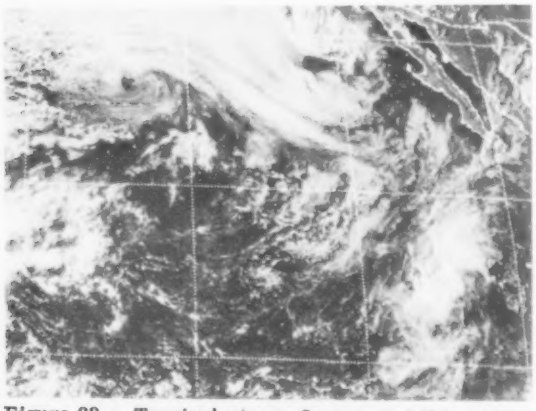


Figure 22.--Tropical storm Joanne at 15°N, 115°W, is moving northwestward at 6 kn with 35- to 40-kn winds near the center. Remnants of hurricane Iva can be seen near 26.7°N, 133.7°W, at 0015 September 4.

HURRICANE KATHLEEN, September 7-10

Kathleen, the fifteenth tropical cyclone of the season, began as a tropical disturbance 300 mi southwest of Acapulco, Mexico, at 0000 September 6. The disturbance, centered near 13°N, 103°W, within an area of intense thunderstorm activity 600 mi in diameter, began to move rapidly toward the west-northwest. By 0600 on the 7th, the disturbance had moved to 15°N, 109°W, 360 mi southwest of Manzanillo and, with 25-kn winds near the center, was upgraded to a tropical depression. The LEVEN FISHER, 130 mi to the east-southeast, reported southwesterly 10-kn winds, continuous moderate rain, and a pressure of 1008.5 mb. By 1800 the depression had moved only 12 mi south of its 0600 position, and the LEVEN FISHER, 30 mi to the northwest, reported a pressure of 1003.7 mb. Another ship, the PIONEER CONTENDER, 210 mi northwest of the depression, reported south-southeasterly 20-kn winds and a pressure of 1009.1 mb. Socorro Island, 260 mi north-northwest of the depression, reported east-northeasterly 10-kn winds. Winds near the center increased to 35 kn by 0000 September 8, and the depression was upgraded to tropical storm Kathleen near 15.5°N, 105.3°W, still about 360 mi southwest of Manzanillo. The PIONEER CONTENDER, 180 mi to the northeast, reported southeasterly 25-kn winds. Winds on Socorro Island, still out of the east-northeast, had increased to 20 kn. Moving northwestward over 83°F water, Kathleen intensified rapidly with winds to 55 kn by 0600 and the center near 16°N, 109.8°W, 180 mi south-southeast of Socorro Island. Winds on the Island increased steadily as Kathleen approached from the south and reached 50 kn from the southeast by 0000 September 9. The storm passed 60 mi to the west of the Island at 0300, and by 0600 winds on Socorro, still from the southeast, had decreased to 35 kn (fig. 23). Kathleen was then 60 mi northwest of the Island. Turning north-northwestward, the storm passed over the western edge of an area of very warm (87°F) water off the southern tip of Baja California. Drawing additional energy from the warm water on its eastern side, Kathleen began to intensify and accelerate rapidly northward. By 1800 the center was at 23°N, 113.3°W, 180 mi west of the tip of Baja California. The CONON FOREST, 80 mi north-northeast of the center, reported easterly 35-kn winds and heavy intermittent rain. The AMERICAN LEADER, 160 mi east of the storm and near the tip of Baja, reported southeast-

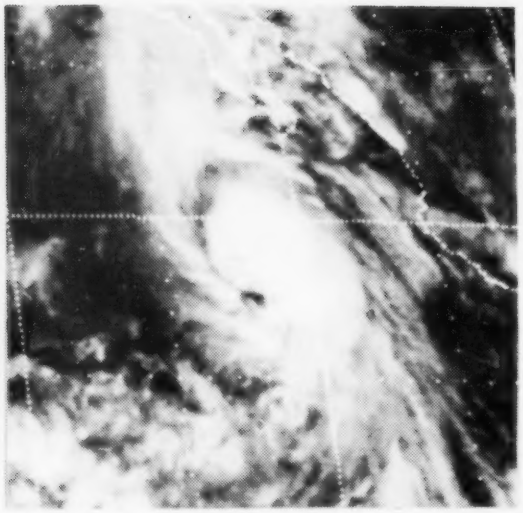


Figure 23.--Tropical storm Kathleen at 0415 September 9 is near 18.9°N, 112.1°W, moving north-northwestward at 10 kn with 60-kn winds.

erly 45-kn winds. The GOLDEN EXPLORER, 190 mi northwest of Kathleen, reported north-northeasterly 20-kn winds and light rain. Winds on Socorro Island, then 290 mi to the south-southeast, had diminished to 10 kn from the south. Turning to the north and moving rapidly at 20 kn, Kathleen was upgraded to a hurricane with 70-kn winds near the center at 0000 September 10 at 25°N, 114°W. The CONON FOREST, 40 mi to the east, reported southeasterly 40-kn winds, and the AMERICAN LEADER reported southerly 40-kn winds 130 mi east-southeast of Kathleen. At 0046 September 10, U.S. Air Force reconniassance aircraft located the storm's center at 25.3°N, 114.8°W. Surface winds were estimated at 80 kn and pressure at 986 mb. A second flight at 0145 estimated the surface winds at 55 kn and pressure at 990 mb. After a brief existence as a hurricane, Kathleen was downgraded to a tropical storm with 55-kn winds at 0600 September 10 near 26.8°N, 114.4°W. Accelerating northward at 30 to 33 kn, Kathleen crossed the western tip of Point Eugenia Peninsula on the west coast of Baja California between 0700 and 0800, then moved onshore 140 mi south of Ensenada, Mexico, at 1130. Kathleen continued northward over the Sierra San Pedro and Juarez mountains entering southern California near Calexico at 1800. Racing across the southern California desert, Kathleen began to weaken. The storm moved northward through Death Valley and into western Nevada, 140 mi southeast of Reno, by 0600 on the 11th. The center was difficult to locate after 0600; however, gusty winds and rain continued to spread northward into eastern Oregon, Idaho, Montana, Utah and Wyoming.

HURRICANE LIZA, September 25 - October 1

Liza, the hurricane that brought death and destruction to the city of La Paz on the tip of the Baja California peninsula, began on September 25 as an area of intense thunderstorm activity 400 mi in diameter near 12.5°N, 106°W. By 1800 September 25, satellite pictures indicated cyclonic circulation about the center of the disturbance, and it was upgraded to a tropical depression with 25-kn winds near 13°N, 107°W. Winds increased to 35 kn by 1800 September 26, and the depression was upgraded to tropical storm Liza near 14°N, 108.5°W, 620 mi south of La Paz. Turning northward and moving at 5 kn over warm (85°F) water, Liza began to intensify. By 1800 September 27, the center with 55-kn winds had moved to 16.3°N, 108.2°W. At 1730 September 28, U.S. Air Force reconnaissance aircraft located the center of Liza 400 mi south of La Paz near 18°N, 108°W. Surface winds were estimated at 40 kn and sea-level pressure at 971 mb. Although not visible on satellite pictures, Liza had developed a 15-mi diameter, closed-wall eye. She moved north at 5 kn, winds increased to 65 kn by 1800, and the storm was upgraded to a hurricane near 18°N, 108.1°W. The KISU MARU, 150 mi to the southwest, reported northwesterly 30-kn winds, and the SPAIN MARU, 120 mi to the north, reported easterly 20-kn winds with continuous moderate rain. At 1923 a second flight through the hurricane by U.S. Air Force reconnaissance aircraft fixed the center at 18°N, 108.2°W. Surface winds were now estimated at 65 kn and sea-level pressure at 968 mb. Winds increased to 70 kn near the center by 0000 September 29 near 18.3°N, 107.9°W. The KISO MARU reported westerly 35-kn winds and violent rain showers 120 mi to the south. Socorro Island, 180 mi to the west, reported west-northwesterly 10-kn winds. By 1200 winds on Socorro shifted to the northwest and increased to 40 kn. Liza was now at 19°N, 108°W, 340 mi south of La Paz. Air Force reconnaissance penetrated the hurricane at 1204 September 29 and computed surface pressure near the center at 948 mb. The hurricane's eye was now visible for the first time on infrared satellite imagery and had become elliptical with the 14 mi long major axis orientated north-northwest/south-southeast (340° to 160°). Continuing northward, Liza continued to move over warmer (86°F) water. The INGER, 110 mi east-northeast of Liza and 30 mi off the Mexican coast at 1500, reported southeasterly 50-kn winds and violent rain showers. The U.S. Air Force made another flight through Liza at 1800, locating the center at 19.3°N, 107.9°W. Surface winds were estimated at 110 kn and pressure at 941 mb. The eye was again circular with concentric walls 10 and 30 mi in diameter. INGER, still 110 mi east-northeast of the center, reported southeasterly 60-kn winds and continued violent rain showers. The PHRYNE, 120 mi south-southeast of Liza, reported southwesterly 35-kn winds and 16-ft swells. The GRAFTON, 150 mi south of the hurricane, reported southwesterly 30-kn winds, and the RHINE MARU reported northwesterly 30-kn winds 180 mi to the west-southwest. By 0000 September 30, Liza with 110-kn winds had moved to 20°N, 107.9°W, 280 mi south of La Paz. The MOGAMISAN MARU, 110 mi east-northeast of Liza and 30 mi off the Mexican coast, reported southeasterly 35-kn winds. The INGER, 120 mi east of the hurricane and 15 mi off the coast, reported southeasterly 45-kn winds and 24-ft seas. Socorro Island, 190 mi west-southwest of Liza, reported west-northwesterly 35-kn winds. At 1500 the RICHARD, 110 mi south-southeast of the hurricane, reported a sudden drop in sea

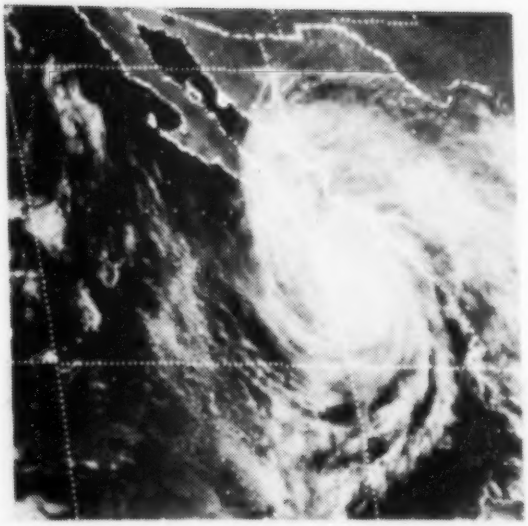


Figure 24.--La Paz was feeling the devastating effects of hurricane Liza as the storm moved northward over the tip of Baja California at 1815 September 30. Winds near the center were 115 kn with gusts to 130 kn.

surface temperature. As a result of upwelling induced by Liza's winds, the water temperature had dropped from 88°F 12 hr earlier to 80°F at 1500.

Moving north at 8 kn over warm (86°F) water, Liza continued to intensify, gathering additional energy from the warmer (88°F) water along its eastern side. At 1725 September 30, the Air Force flew another reconnaissance flight through the hurricane, locating the center at 22.1°N, 109.3°W, 140 mi south of La Paz. Surface winds were estimated at 125 kn and pressure at 939 mb (fig. 24). The diameter of the eye had increased to 20 mi with a 2 mi thick closed wall. The OAKLAND, 90 mi west of Liza at 1800, reported northerly 30-kn winds in the lee of the tip of Baja California. By 0000 October 1, Liza was 50 mi east-southeast of La Paz at 23.8°N, 109.3°W. The FAIRSEA and PHRYNE, 150 and 200 mi south of Liza, reported westerly 40-kn winds. At 0200 Liza passed 45 mi east of La Paz with 115-kn winds and gusts to 130 kn. An estimated 5 to 6 in of rain fell over the southern end of Baja peninsula causing considerable damage and several hundred deaths. Moving rapidly northward over the southern end of the Gulf of California, Liza moved onshore with 100-kn winds on the west coast of Mexico 45 mi north of Los Mochis at 1300. Weakening rapidly, the storm accelerated across northern Mexico at 25 to 30 kn.

HURRICANE MADELINE, September 29 - October 8

Madeline began as a tropical disturbance on September 27 near 9°N, 91°W, 300 mi south of the coast of Guatemala and 700 mi southeast of Acapulco. At 2100 on the 28th, the SEATIGER was 70 mi south of the disturbance with 40-kn south-southwesterly winds and heavy continuous rain. Satellite pictures indicated cyclonic circulation about the center, and the disturbance was upgraded to tropical storm Madeline with 35-kn winds near the center at 10°N, 90.5°W, at 0000 September 29. By 1200 satellite pictures showed considerable weakening of the storm, and Madeline was downgraded to a tropical depression with 30-kn winds near 10°N, 91.1°W. The STAR MALMANGER, 120 mi north-northeast of the depression at 0000 on September 30, reported southeasterly 30-kn winds. By 1800 winds had diminished to 25 kn with circulation no longer evident about the center; the depression was downgraded to a tropical disturbance near 11.5°N, 92°W, about 500 mi southeast of Acapulco. It then turned westward and moved at 4 kn slowly regenerating. The T.S. PETERSEN, 70 mi east of the disturbance at 0000 October 1, reported southeasterly 25-kn winds. The AMERICAN ASTRONAUT, 40 mi south-southwest of the disturbance at 0000 October 2, reported northwesterly 25-kn winds and heavy intermittent rain. By 1800 the disturbance had moved to 12°N, 95°W, and the MUST LLOYD, 60 mi to the north, reported easterly 25-kn winds. Satellite imagery indicated cyclonic circulation about the center by 0000 on October 3, and the disturbance was upgraded to a tropical depression with 30-kn winds near 11.8°N, 95.5°W, 400 mi southwest of Acapulco. Turning to the southwest, the depression moved to 10.5°N, 97.5°W, by 1800 on October 4 and remained almost stationary for the next 18 hr. By 0000 on the 5th, winds near the center had increased to 35 kn, and the depression was upgraded to tropical storm Madeline again at 10.5°N, 97.5°W, 400 mi south-southeast of Acapulco. Madeline turned north-northwestward after 1200 and, with warmer (85°F) water on its northeast side, began to intensify rapidly. By 0000 October 6, the storm had moved to 12.1°N, 98.4°W, and winds had increased to 55 kn. The storm was upgraded to a hurricane with 70-kn winds near 13.1°N, 100.3°W, 200 mi south of Acapulco at 1800 October 6. The NEW YORK MARU, 200 mi to the northeast, reported 35-kn southeasterly winds and heavy continuous rain. Air Force reconnaissance aircraft located the center at 1815 at 13.1°N, 100.4°W, with winds estimated at 65 kn and pressure at 984 mb. Madeline's eye, first visible on satellite pictures at 1615, was reported as well defined with a 30-mi diameter. By 0000 October 7, Madeline was 200 mi south-southwest of Acapulco with 70-kn winds at 13.9°N, 101°W. The TASMANIC, 150 mi south-southeast of the center, reported southwesterly 35-kn winds and heavy intermittent rain. The THOMPSON LYKES, 180 mi east of the hurricane, reported southerly 30-kn winds and continuous moderate rain. The SANTA MAGDALENA, 110 mi northwest of Madeline, reported east-northeasterly 35-kn winds. At 1117 October 7, Air Force reconnaissance aircraft again located the center at 14.9°N, 102°W, 170 mi southwest of Acapulco and 160 mi south of Zihuatanejo. Surface winds were estimated at 75 kn, and the eye had increased to 40 mi in diameter. Moving north over 82°F water with warmer (85°F) water along its eastern side, Madeline continued to intensify. By 1800 winds had increased to 110 kn with the center at 15.4°N, 102.1°W. The NORSE VIKING, 100 mi northeast of the center and 30 mi off the coast, reported easterly 60-kn winds and heavy continuous rain. The ECUADORIAN REEFER, 70 mi east-northeast of the hurricane, reported southeasterly 55-kn winds and heavy intermittent rain. The ELIZABETH LYKES, 190 mi east of Madeline, reported east-southeasterly

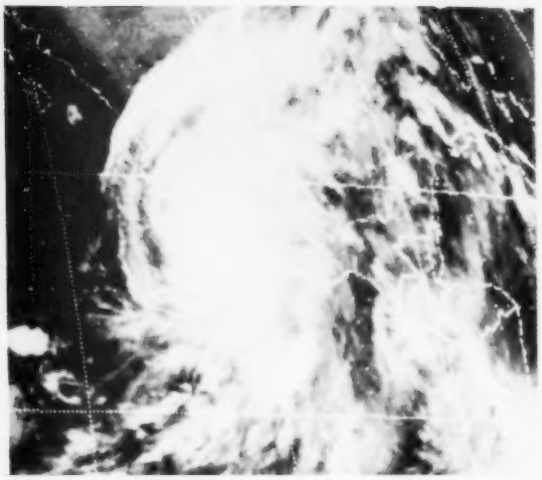


Figure 25.--The eye of hurricane Madeline is about to strike the Mexican coast at 0415 October 8. Winds were 120 kn, gusting to 135 kn.

Figure 26.--Infrared imagery of tropical storm Naomi at 1045 October 28. The storm was centered near 20.2°N, 112.1°W, and moving northeastward at 10 kn with 40-kn winds.

25-kn winds and heavy continuous rain. The WONORATO, 120 mi northeast of the center, reported 35-kn southeasterly winds and heavy intermittent rain. By 0000 on October 8, Madeline, with 115-kn winds, had moved to 16.2°N, 102°W, 140 mi west of Acapulco and 100 mi south of Zihuatanejo. The CHEVRON GENOA, 140 mi to the east, reported east-southeasterly 45-kn winds and heavy intermittent rain. The EXXON BALTIMORE, 80 mi to the north-northwest, reported northerly 50-kn winds. The MEONIA, 80 mi to the east-northeast, reported east-southeasterly 45-kn winds with heavy continuous rain. At 0030 October 8, Air Force reconnaissance aircraft located the center near 16.2°N, 102°W, with winds estimated at 120 kn and pressure at 941 mb. A second penetration by the aircraft at 0209 reported a pressure of 940 mb and eye diameter down to 30 mi (fig. 25). Winds increased to 125 kn gusting to 140 kn by 0600 October 8 with the center near 17°N, 102.1°W, 80 mi west of Acapulco and 50 mi southwest of Zihuatanejo. The AUSTRAL LIGHTNING, 50 mi to the northwest, reported northerly 100-kn winds and heavy continuous rain. The FINN LEONHARDT, 120 mi to the east, reported 40-kn southeasterly winds. The AUSTRAL LIGHTNING was 60 mi south-southwest of the hurricane by 0900 still reporting heavy continuous rain, but the winds had shifted to southwesterly at 75 kn. Madeline moved onshore 45 mi northwest of Zihuatanejo at 1100 on October 8 and weakened rapidly.

TROPICAL STORM NAOMI, October 25-29

Naomi, the eighteenth and last tropical cyclone of the 1976 season, began as a disturbance at 1800 October 22, near 11°N, 112°W, 800 mi south-southwest of Mazatlan. The DAVID STAR JORDAN, 180 mi to the east-southeast, reported southerly 20-kn winds and the FORTHBANK, 90 mi to the north, reported northeasterly 20-kn winds. The disturbance moved westward to 11°N, 115°W, by 1200 October 23, then turned northward to 15°N, 116°W, by 1200 October 24. Moving over 83°F water with warmer (85°F) water on its eastern side, the disturbance began to intensify and was upgraded to a tropical depression with 30-kn winds at 0600 on the 25th near 16.8°N, 115.6°W. Winds near the center increased to 35 kn by 1800, and the depression was upgraded to tropical storm Naomi near 16.8°N, 115.8°W, 660 mi southwest of Mazatlan. The ARCO ENTERPRISE, 60 mi to the west-northwest, reported northerly 35-kn winds and intermittent moderate rain. By 0000 on the 26th, the storm had moved to 17°N, 116°W, and the TITUS, 100 mi to the south-southwest, reported southwesterly 20-kn winds. Naomi turned northeastward to 18.6°N, 114.2°W, by 1800 October 27. Winds near the center increased to 45 kn. Satellite pictures showed Naomi with a diameter of about 200 mi and a 200 to 300 mi wide band of high-level clouds flowing from the center east-northeastward across central Mexico. By 0600 on the 28th, the storm had moved to 19.8°N, 112.5°W. The LEIDERKERK, 110 mi to the west-northwest, reported northerly 25-kn winds. Accelerating northeastward at 12 kn (fig. 26), Naomi moved to 21.5°N, 111.2°W, 110 mi southwest of the tip of Baja California and 280 mi west-southwest of Mazatlan, by 1800.

At 1816 October 28, Air Force reconnaissance aircraft estimated the center of the storm near 21.6°N, 111.1°W, but was unable to confirm the position due to extensive low clouds. Surface winds were estimated at 40 kn and pressure at 1005 mb. By 0000 October 29, Naomi had moved to 21.5°N, 110°W, 90 mi south of the tip of Baja and 225 mi west-southwest of Mazatlan. The MEIKO MARU and MITO MARU, 40 and 65 mi to the east, reported southerly 30-kn winds. The MARCONA EXPORTER, 20 mi to the south, reported 30-kn southwesterly winds, and the BEL CARGO, 25 mi to the north-northwest, reported winds as high as 50 kn. Accelerating northeastward at 18 kn, Naomi moved to 22.8°N, 106.8°W, 30 mi southwest of Mazatlan by 1200. Naomi moved onshore near Mazatlan at 1330 October 29 with 35-kn winds near the center. The storm weakened rapidly as it moved northeastward across the Sierra Madre Mountains.

GREAT LAKES NAVIGATION SEASON, 1976

Elwyn E. Wilson
Environmental Data Service, NOAA
Washington, D. C.

There was continuous traffic through the Great Lakes system this calendar year. The United States Soo Lock system on the St. Marys River remained in operation during the entire year. The Canadian Soo Lock opened on April 5. The St. Lawrence Seaway and Welland Canal target opening date was April 1, but traffic did not begin until April 3 owing to adverse weather and ice conditions.

The first westbound vessel in the Seaway was the Yugoslavian ALKA (fig. 27) which entered the St. Lambert Lock on April 3. It was also the first saltie to arrive at several lake ports including Toronto, Cleveland, Detroit, Toledo, Chicago, and Green Bay. Eastbound traffic was led by the Canadian freighter LAKE MANITOBA also on the 3d.

The first vessel to complete passage of the 27-mi Welland Canal was the CANADIAN LEADER on April 1. The same day, transit upbound was made by the H.M. GRIFFITH. The OPATIJA passed the ALKA which had stopped at Toronto and became the first salt-water traffic through the Welland on the 6th.

At the Soo Locks, the new statistical year started April 1, with the YANKCANUCK being the first vessel through (fig. 28).

There were plans for United States and other flag lines to increase the direct service to foreign ports (fig. 29). During the latter half of July, eastern Lake Ontario was the center of attention as the 1976 Olympic sailing competition was held off Kingston, Ontario (fig.

Figure 28.--The YANKCANUCK with boom up is part of a convoy on the St. Clair River during January 1976. From top to bottom, the vessels are the BRAMBLE, GRIFFON, YANKCANUCK, and the MARIPOSA.

Figure 27.--The ALKA was the first "saltie" to enter the Lakes during the 1976 navigation season. Photo courtesy of Great Lakes Commission.

Figure 29.--There was an increase in foreign shipping on the Lakes. Here the Danish heavy-lift ship HEAVY SCAN loads a 150-ton mobile crane at Toledo. Photo courtesy of Great Lakes Commission.

30). The British royal yacht BRITANNIA arrived with the royal family. The Lakes were also visited by some of the "Tall Ships" that participated in the Bicentennial pageant Operation Sail in New York Harbor on July 4. Included were the CHRISTIAN RADICH, ERAWAN, and MAY. The French and Italian destroyers DUPERRE and SAN GIORGIA of the International Naval Review also made goodwill tours (fig. 31). Two new lakers were christened this year--the 1,000-ft JAMES R. BARKER (fig. 32) and the 770-ft ST. CLAIR (fig. 33).

Figure 31.--This striking photograph shows the USCGC EAGLE under full sail. The vessel hosted the "Tall Ships" bicentennial review in New York. Several of these outstanding sailing vessels visited the Lakes.

Figure 30.--Sailboats approach the starting line for the U.S. Olympic trials off Kingston, Ontario.

Figure 32.--The JAMES R. BARKER, the first 1,000-ft vessel built entirely on the Great Lakes, was christened on August 7 and placed in service the same day. Photo courtesy of Great Lakes Commission.

Figure 33.--The 770-ft ST. CLAIR was christened at Sturgeon Bay, Wis., on April 22. She was built specifically to carry western low-sulfur coal. Photo courtesy of Great Lakes Commission.

The scheduled closing dates of December 18 for the St. Lawrence Seaway and December 30 for the Welland Canal were delayed until December 24 and January 3, 1977, respectively, by exceptionally severe ice conditions throughout the Great Lakes-St. Lawrence Seaway system. Final passages through the Seaway were the latest since it began service. The freighter ATTICA cleared the St. Lambert Lock downbound, and the SEAWAY QUEEN transited the Iroquois Lock upbound. The ATTICA was delayed owing to a crack in the hull which was temporarily repaired. She was the last overseas ship through the Welland Canal on December 19 under tugboat escort. The downbound FRONTENAC (fig. 34) entered the Canal on December 29, but did not clear until 5 days later on January 3, 1977. The freighter TARANTAU became stuck in the ice above lock 7, midway along the Canal, and was tied up for the winter. Thus, the BLACK BAY made the final passage into Lake Erie on December 29.

The Canadian Soo Lock closed on December 12. The last of the ocean traffic to transit the American Soo Locks was the AMALIE on December 14. These locks continued to operate into the new year, but traffic was interrupted by ice conditions and groundings.

Figure 34.--A tiny tug helps the icebound FRONTENAC on the Detroit River. Later, it took her 5 days to clear the Welland Canal. Wide World Photo.

All of the lakes were above the low-water datum and the 1900-75 average except Lake Superior, which was below average during the last part of the year.

Total precipitation for the Great Lakes Basin averaged 31.06 in for 1976, about two percent below the annual average. The Lakes were considerably below their long-term averages during the last half of the year. Lakes Superior and Michigan, which comprise about half of the total basin area, were 40 and 45 percent below average. The Huron, Erie-St. Clair, and Ontario lake basins were slightly above normal for the year. Table 6 shows annual precipitation data for 1972-76 with this year's departure.

Table 6.--Annual precipitation data for 1972-76

	Great Lakes	Lake Ontario	Lake Erie	Lake Huron	Lake Michigan	Lake Superior
1972 (in)	35.97	43.67	39.70	35.32	34.97	32.22
1973 (in)	33.87	38.16	37.01	32.34	33.98	30.84
1974 (in)	28.94	33.42	34.14	25.92	32.77	23.86
1975 (in)	34.62	38.53	38.95	34.58	35.74	29.91
1976 (in)	31.06	40.92	35.88	33.43	26.54	25.97
1976/average	-0.53	+6.43	+1.95	+2.06	-4.75	-3.62

NOAA NATIONAL WEATHER SERVICE AIDS

Weather and ice services were provided as needed throughout the entire 1976 season with continued navigation. This was the second year in a row that navigation proceeded without a break in the upper Great Lakes.

Few changes can be noted in the National Weather Service program. Four major Weather Service Fore-

cast Offices (WSFO) provided open lake forecasts (MAFORS) for open waters, and an additional network of 15 offices made nearshore forecasts during the summer season from April through October.

Marine radio stations throughout the Lakes broadcast routine weather information during the season. The Lorain Electronics network was expanded during the year as VHF-FM took over from the AM system, which was officially phased out at the end of December. Central Radio, based in Rogers City, also added a station to their network at Sault Ste. Marie, Mich. Coast Guard radio stations continued to broadcast warning messages as required throughout the year. NOAA-Weather Radio was expanded to include facilities at Alpena, Traverse City, and Flint, Mich., and Rochester, N.Y.

During the ice season, the National Weather Service provided wind and temperature forecast charts via radiofacsimile. The agency also cooperated with the U.S. Coast Guard and the Lewis Research Center of NASA in Cleveland, Ohio, to provide side-looking airborne radar (SLAR) imagery of ice conditions to shipping. Ice forecast services originated from WSFO Detroit and through the Ice Navigation Center in Cleveland.

Fewer major storms were reported in the Great Lakes in 1976 than in the previous season. There were 15 storm warnings in 1976 compared to 43 in 1975. There was a 34-percent increase in gale warnings, however; in the five lakes with year-round navigation, 311 gale warnings were issued in 1976 and 233 in 1975. Totals for all lakes for 1976 were 15 storm warnings and 385 gale warnings.

ICE SEASON

Winter got off to an early and severe start. Coast Guard records indicate that beginning December 3, 1976, there were 248 incidents where aid was provided to icebound vessels in the month. This compares to 15 similar assists for the same period in 1975. Along the St. Lawrence River, water temperatures were reported as the lowest since the opening of the Seaway on December 8, 1959. Shipping was halted in the Beauharnois Canal from December 12 to 14 to permit a stable ice cover to form to reduce the chance of damage to hydroelectric turbines. Fifty overseas ships were still in the Lakes-Seaway system at that time. In addition to ice on the Lakes, localized deep snow hampered land transportation to ports. Deep snow along the lee or eastern sides of the Lakes is enhanced in the adjacent uplands (fig. 35). This lake effect is produced where cold air masses move over relatively warm lake waters and pick up moisture in their lower layers. This is then precipitated as snow when further cooled, such as by lifting by terrain. The greatest mean annual snowfall areas are southeast of Lakes Ontario and Superior. The record depth for one season in the Great Lakes Basin appears to be at least 449 in at Sears Pond, N.Y., near Watertown in 1976-77. Tahquamenon Falls State Park in upper Michigan had 329 in at the time of this writing.

The ice was so thick by the first week of December that ships became stuck. On the 3d, the HARRY L. ALLEN and JAN T. HUTCHINSON were stuck downbound in Lake St. Clair. The next week the CLIFFS VICTORY went aground while trying to avoid ice jams on the St. Marys River on the 11th. This was described as the worst traffic jam in 50 yr with more than 60 vessels tied up (fig. 36).

Conditions did not improve in January 1977. The BENJAMIN F. FAIRLESS in Lake Superior and three ships on the St. Marys River were stranded until freed by the Coast Guard. Ore shipments on the St. Marys River were halted on January 18 and not resumed until March 15. Some intermittent traffic continued on the Lakes, mainly emergency fuel cargoes. Barge traffic on the midwestern river system was slowed and completely halted at times by ice and ice gorges. Satellite

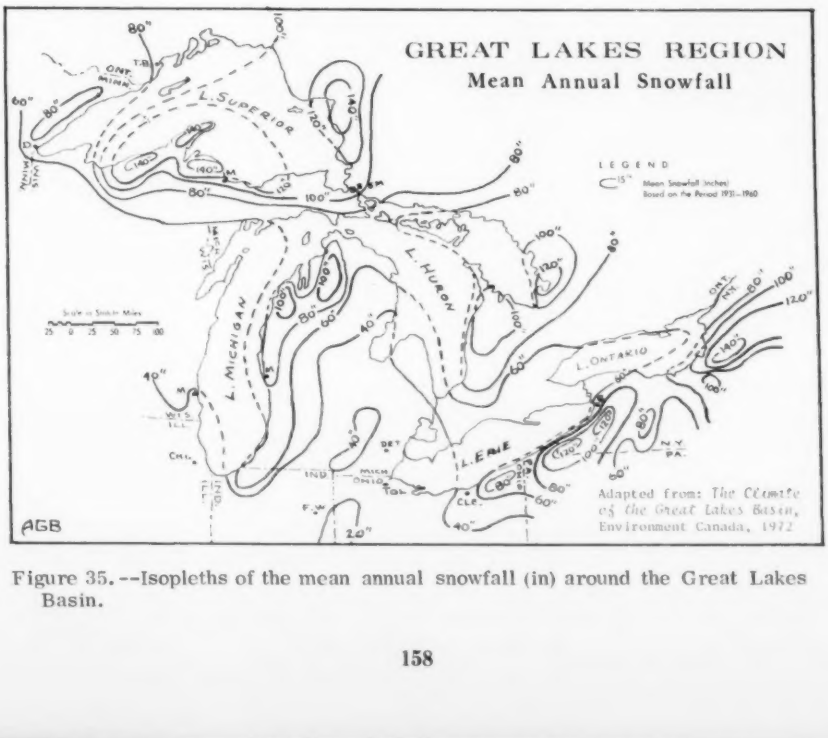


Figure 35.--Isopleths of the mean annual snowfall (in) around the Great Lakes Basin.

Figure 36.--The 716-ft CLIFFS VICTORY in the St. Marys River after being freed from shoals. The tug JOHN ROWAN and Coast Guard cutter MACKINAW aided. The grounding caused a backup of nearly 60 ships in the Soo area. Wide World Photo.

pictures showed snow cover over 65 percent of North America during January. In early February, Lake Michigan froze over--a rare occurrence.

Warmer weather in March helped deterioration of the ice cover, and the Seaway system was opened for navigation on April 4.

GREAT LAKES OBSERVATION PROGRAM

Thirty-one Great Lakes weather reporting ships participated in the program this season. A total of 10,405 observations were received by the National Climatic Center in Asheville, N.C. This was an increase of 285 observations over 1975, reversing the trend of the last few years. The following number of observations by lake were reported: Lake Ontario, 15 by 4 ships; Lake Erie, 709 by 28 ships; Lake Huron, 2,824 by 31 ships; Lake Michigan, 1,579 by 27 ships; Lake Superior, 5,278 by 30 ships.

Ships reported gales (34 to 40 kn) the following number of days: Lake Ontario, 1; Lake Erie, 14; Lake Huron, 38; Lake Michigan, 38; Lake Superior, 63. Strong gales (41 to 47 kn) were reported 2 days on Lake Erie, 8 days on Lake Huron, 5 days on Lake Michigan, and 18 days on Lake Superior. Storm winds (48 to 55 kn) were observed 1 day on Lake Erie, 2 days on Lake Huron, 1 day on Lake Michigan, and 1 day on Lake Superior. Violent storm winds (56 to 63 kn) were observed 1 day on Lake Huron during January.

There were the most days in December with high-wind observations followed by October and November. November had the most observations with winds greater than 30 kn. This was only slightly higher than December, but there were probably more ships operating in November. Table 7 shows high-wind observations by 10-kn categories.

Table 7.--Number of high-wind observations during calendar year 1976

High-wind categories	Observations
Over 30 kn	541
Over 40 kn	47
Over 50 kn	3

There were 34 observations made of seas over 12 ft; 30 of seas 13 to 15 ft; and 4 of seas 16 to 20 ft. No seas over 20 ft were reported. November had the most days and observations with seas over 12 ft, but October had the most waves over 15 ft. The highest waves were 16.5 ft reported in March by the PHILIP R. CLARKE, in July by the ARMCO, and in October by the CHARLES M. WHITE and JOHN SHERWIN. Seas over 12 ft were reported 6 times on 5 days on Lake Erie, 6 times on 6 days on Lake Huron, 3 times on 3 days on Lake Michigan, and 19 times on 15 days on Lake Superior.

Tables 8 through 15 give summaries of the maximum winds for each lake by month, the highest wind by month on any lake, the highest 1-min wind by lake for each year since 1941, and the highest seas reported on each lake this year. The tables include only those observations that were logged and forwarded on Great Lakes Observation Form 72-2.

NOTABLE WEATHER HAPPENINGS

INTRODUCTION

Again, December led with the most days with high winds, and November had the most observations. January produced the highest wind of 56 kn recorded

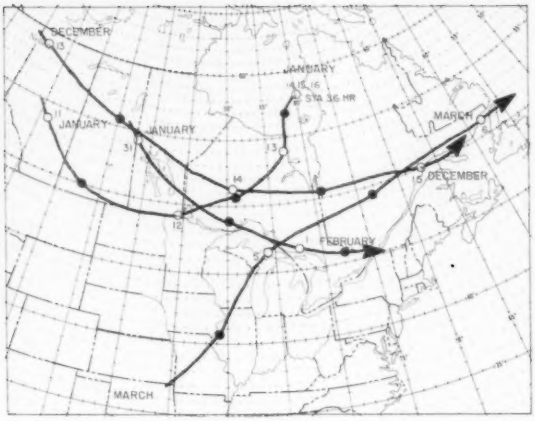


Figure 37.--Tracks of 1975 Great Lakes storms with winds greater than 50 kn. Open circles indicate the position of the center at 1200 of date shown. The closed circle indicates the 0000 position.

by the G.M. HUMPHREY on Lake Huron. The seas were 10 ft. The four high-wave reports of 16.5 ft were on Lake Erie (which had two) Lake Huron, and Lake Superior.

Of the 591 observations of winds over 30 kn, there were 4 reports of thunderstorms at the time of observation, 9 reports of squalls, 1 report of during past hour, and 8 reports in past weather. Some of the present weather and past weather reports were in the same observation. There were 8 special observations that indicated some kind of severe weather. Although no waterspouts were reported on synoptic observations, the PAUL H. CARNAHAN reported 7 with a line of thunderstorms over Lake Erie on September 21 on a special observation.

June had the largest number of observations with visibility below 2 mi with 141 or 10.3 percent of the total for the month. May was the second highest with 96 or about 8 percent. Surprisingly, December came in third with 84 observations and 16 percent.

The largest amount of ice accretion on a ship was 5 in on the LEON FRASER on January 8 on Lake Michigan. The ship was sailing in fog with -26°C temperature. Two days later on northern Lake Michigan, she indicated "Fast in Ice" in the remarks column. This was one of ten remarks concerning ice on the Lakes.

The following paragraphs describe by months some of the more severe storms as indicated by the observations. February and March are not included because ~~of the few boats operating and sparsity of observatio~~ of few boats operating and sparsity of observations. Figure 37 shows the tracks of the centers of the more intense storms.

JANUARY

The year started with a LOW moving over Lake Superior on the 3d. The CHARLES M. BEEGHLEY was on Lake Superior headed south and radioed the first gale-force winds at 0000 on the 1st. On the 2d, the PHILIP R. CLARKE was on eastern Lake Superior with 32-kn southeasterly winds and snow. By the 4th, the LOW had moved beyond James Bay with a tight gradient between it and a cold HIGH over the Great Plains. The LEON FALK JR was near Toledo with 48-kn westerly winds at minus 9°C. The high pressure moved south of the Lakes on the 5th as another HIGH pushed southward out of western Canada. It brought extremely frigid temperatures ahead of it out of northern Canada. Bitter cold struck the area on the 8th, and lake-effect snowstorms dumped up to 2 ft of snow in 2 days in western New York along Lake Erie. On the morning of the 9th, the ENDERS M. VOORHEES became stuck in ice about 0.7 mi from the Lake St. Clair crib.

This was the storm that brought the highest recorded synoptic time wind of the year. The LOW formed near Edmonton, Alberta, on the 11th and moved eastward. By the 12th, its circulation was being felt over the western lakes. At 0000 on the 13th, the G.M. HUMPHREY was caught by 56-kn southerly winds off Rogers City, Mich., as she headed southeasterly toward Lake St. Clair (fig. 38). The seas were 10 ft at the time. By 0600 winds had decreased

Table 8.--Maximum windspeed reported on Lake Ontario for each month by National Weather Service cooperating vessels, 1976

Month	Kn	Direction	Time (GMT)	Date	Ship	Lat. (°N)	Long. (°W)
January							
February							
March					(No observations received)		
April							
May							
June							
July	24	260°	1800	17	ENDERS M. VOORHEES	43.7	78.0
August	24	080°	0600	24	ENDERS M. VOORHEES	43.5	78.5
September	30	270°	0000	23	LEON FRASER	43.8	77.1
October	34	260°	1800	28	BENJAMIN F. FAIRLESS	43.7	77.1
November	32	250°	0600	14	ENDERS M. VOORHEES	43.5	78.5
December				(No observations received)			
Year	34	260°	1800	Oct. 28	BENJAMIN F. FAIRLESS	43.7	77.1

Table 9.--Maximum windspeed reported on Lake Erie for each month by National Weather Service cooperating vessels, 1976

Month	Kn	Direction	Time (GMT)	Date	Ship	Lat. (°N)	Long. (°W)
January	48	270°	1200	04	LEON FALK JR	41.7	82.5
February				(No observations received)			
March	18	080°	0600	29	LEON FRASER	41.6	82.3
April	38	060°	0000	25	CHAMPLAIN	41.9	82.1
		020°	1800	25	CHAMPLAIN	41.9	82.6
May	33	260°	0000	03	CHARLES M. BEEGHLY	41.9	82.2
		360°	0600	18	SAMUEL MATHER	41.9	82.5
June	30	030°	1800	02	WILLIS B. BOYER	41.6	81.7
July	34	330°	1200	12	LEON FALK JR	42.2	81.0
August	28	020°	0600	08	ENDERS M. VOORHEES	42.0	80.8
September	43	290°	1200	11	J. L. MAUTHE	42.2	81.8
October	40	210°	0600	15	SAMUEL MATHER	42.1	81.7
		260°	1800	21	SAMUEL MATHER	42.1	82.4
November	46	260°	0000	30	G. M. HUMPHREY	42.4	80.5
December	35	210°	1800	10	G. M. HUMPHREY	41.7	82.2
Year	48	270°	1200	Jan. 04	LEON FALK JR	41.7	82.5

Table 10.--Maximum windspeed reported on Lake Huron for each month by National Weather Service cooperating vessels, 1976

Month	Kn	Direction	Time (GMT)	Date	Ship	Lat. (°N)	Long. (°W)
January	56	170°	0000	13	G.M. HUMPHREY	45.5	83.4
February	24	260°	0600	13	ARTHUR M. ANDERSON	45.9	84.3
March	29	310°	0000	15	PHILIP R. CLARKE	45.9	84.3
April	42	360°	0600	11	JOHN DYKSTRA	45.0	83.1
May	36	300°	0600	03	CHAMPLAIN	44.7	83.1
June	30	220°	0000	11	PAUL H. CARNAHAN	43.8	82.5
		050°	1800	30	RESERVE	44.5	82.7
July	48	040°	0000	01	ARMCO	44.8	82.7
August	34	320°	1200	29	CLIFFS VICTORY	45.2	83.2
September	46	270°	1800	23	JOHN DYKSTRA	45.1	83.2
October	48	260°	1200	28	WILLIAM A. REISS	44.3	83.0
November	39	260°	0000	23	CHARLES M. WHITE	44.1	82.8
December	45	260°	1800	14	SAMUEL MATHER	46.0	83.9
Year	56	170°	0000	Jan. 13	G.M. HUMPHREY	45.5	83.4

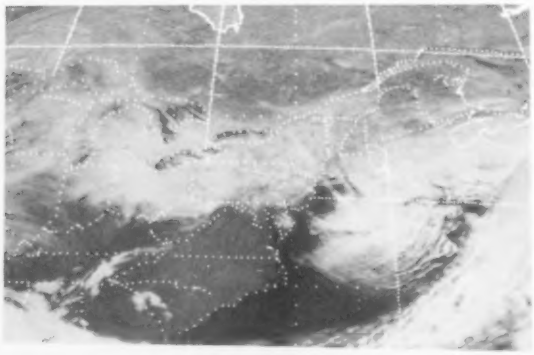


Figure 38.--The storm that produced the highest winds of the year at 1700 on the 12th.

to 31 kn. The LEON FRASER had 32-kn gale-force winds on Lake Superior.

On the 13th, the gradient relaxed as another LOW moved northeastward from the Midwest. By 1200 on the 14th, this new LOW had moved to near Montreal, and the other LOW was over Hudson Bay. The gradient southwest of the two LOWs tightened again due to high pressure over the Great Plains. The PHILIP R. CLARKE was headed northwestward out of Whitefish Bay with 42-kn winds at 1800. She reported gale-force winds until the 16th as she was headed out of Keweenaw Bay. The second LOW continued eastward as the first one drifted over Hudson Bay and dissipated. This LOW formed in the lee of the Rocky Mountains of southern Alberta late on the 14th. By 0000 on the 16th, it was centered over southern Wisconsin. The ENDERS M. VOORHEES on northern Lake Michigan had 32-kn southeasterly winds. At 1800 the LEON FRASER con-

Table 11.--Maximum windspeed reported on Lake Michigan for each month by National Weather Service cooperating vessels, 1976

Month	Kn	Direction	Time (GMT)	Date	Ship	Lat. (°N)	Long. (°W)
January	40	340°	1800	16	LEON FRASER	45.5	86.8
February	55	340°	1200	01	LEON FRASER	45.5	86.6
March	44	220°	0600	14	CASON J. CALLOWAY	43.5	87.4
April	40	020°	1800	25	ELTON HOYT II	42.1	87.3
May	38	330°	0000	03	ELTON HOYT II	45.0	86.6
June	30	220°	0600	14	SAMUEL MATHER	45.1	86.0
July	30	360°	1800	31	ARTHUR M. ANDERSON	43.7	86.7
August	32	030°	0600	15	ENDERS M. VOORHEES	43.8	86.7
		350°	0000	01	LEHIGH	42.2	87.0
September	42	340°	0000	22	JOHN SHERWIN	45.8	85.3
October	40	310°	0000	14	PHILIP R. CLARKE	45.1	86.7
November	38	270°	0000	30	J. L. MAUTHE	44.7	87.2
December	42	340°	1800	20	ENDERS M. VOORHEES	45.2	86.6
		220°	1200	14	ARTHUR M. ANDERSON	44.5	86.5
Year	55	340°	1200	Feb. 01	LEON FRASER	45.5	86.6

Table 12.--Maximum windspeed reported on Lake Superior for each month by National Weather Service cooperating vessels, 1976

Month	Kn	Direction	Time (GMT)	Date	Ship	Lat. (°N)	Long. (°W)
January	42	290°	1800	14	PHILIP R. CLARKE	47.1	86.1
February	46	330°	0600	08	ARTHUR M. ANDERSON	47.6	90.5
March	54	050°	1200	05	PHILIP R. CLARKE	47.8	86.1
April	36	250°	0600	19	J.L. MAUTHE	47.7	88.3
May	39	330°	1800	03	J.L. MAUTHE	47.0	85.8
June	45	240°	1800	24	ENDERS M. VOORHEES	47.1	91.0
July	36	310°	0000	07	WILLIS B. BOYER	47.5	89.5
August	46	190°	1800	27	WILLIS B. BOYER	47.5	89.2
September	46	360°	1200	21	J.L. MAUTHE	47.2	86.7
October	46	280°	0600	15	ENDERS M. VOORHEES	47.0	88.0
November	45	270°	0000	14	WILLIAM A. IRVIN	47.6	87.6
December	46	020°	0600	02	G.M. HUMPHREY	47.3	85.2
Year	54	050°	1200	March 05	PHILIP R. CLARKE	47.8	86.1

tended with 40-kn gales from the north near Green Bay. The storm raced up the St. Lawrence River Valley, and no more high winds were reported.

APRIL

Adverse weather and ice conditions delayed the opening of the St. Lawrence River to traffic from the target date of April 1 to the 3d. From the U.S. Locks south, the River was open. The Canadian Soo Lock opened on the 5th and, of course, the United States Soo was open all winter.

The first storm of the month was really associated with high pressure rather than low pressure. A LOW moved across northern Hudson Bay on the 9th, and a cold front swept through the Lakes late on the 10th and early on the 11th. A 1036-mb HIGH was pushing southward from west of Hudson Bay. The tight gradient between the HIGH, the northern LOW, and another LOW that moved northward to over Newfoundland on the 11th produced strong, northerly winds.

Early on the 11th there were gale warnings for the Lower Lakes along with lowland flooding and beach erosion along Lake Erie and southeastern Lake Michigan, where 8-ft waves were pounding the Indiana beaches. At 0600 on the 11th, the ARMCO was on Lake Huron with 40-kn northerly winds. At 1200 the J. BURTON AYERS had 32-kn winds at the southern end of the Lake. Six hours later, the LEON FRASER was within 2 mi of the AYERS 1200 position with 33-kn winds.

By the morning of the 12th the higher winds had moved to Lake Ontario and waves up to 8 ft were battering its south shore with attendant flooding and erosion. The HIGH turned southeastward, and its center moved south of the Lakes late on the 12th.

There were several weak low centers over the Great Basin on the 22d. These moved eastward and consolidated into a well developed storm on the 24th over the Great Plains. At 0000 on the 25th, the 1000-mb center was near Chicago. The CHAMPLAIN on

Table 13.--Maximum windspeed reported for each month for the Great Lakes by National Weather Service cooperating vessels, 1976

Month	Kn	Direction	Time (GMT)	Date	Lake	Ship	Lat. (°N)	Long. (°W)
January	56	170°	0000	13	Huron	G.M. HUMPHREY	45.5	83.4
February	55	340°	1200	01	Michigan	LEON FRASER	45.5	86.6
March	54	050°	1200	05	Superior	PHILIP R. CLARKE	47.8	86.1
April	42	360°	0600	11	Huron	JOHN DYKSTRA	45.0	83.1
May	39	330°	1800	03	Superior	J.L. MAUTHE	47.0	85.8
June	45	240°	1800	24	Superior	ENDERS M. VOORHEES	47.1	91.0
July	48	040°	0000	01	Huron	ARMCO	44.8	82.7
August	46	190°	1800	27	Superior	WILLIS B. BOYER	47.5	89.2
September	46	360°	1200	21	Superior	J.L. MAUTHE	47.2	86.7
		270°	1800	23	Huron	JOHN DYKSTRA	45.1	83.2
October	48	260°	1200	28	Huron	WILLIAM A. REISS	44.3	83.0
November	46	260°	0000	30	Erie	G.M. HUMPHREY	42.4	80.5
December	46	020°	0600	02	Superior	G.M. HUMPHREY	47.3	85.2
Year	56	170°	0000	Jan. 13	Huron	G.M. HUMPHREY	45.5	83.4

Lake Erie measured 35- to 38-kn winds throughout the day. The SAMUEL MATHER, headed south on Lake Michigan, ran into 40-kn winds and 12-ft seas as she approached Chicago at 1800. On Lake Superior, the ELTON HOYT II had only 32 kn near Whitefish Bay.

Shore warnings for flooding owing to an easterly wind were issued for western Lake Erie late on the 24th. Flash flood warnings were also issued for Milwaukee, where over 2 in of rain fell in 6 hr. A new record rainfall for 15 min was set at Midway Airport in Chicago, where the rain gage measured 1.65 in.

At 0300 on the 25th, the water level at Toledo was 6.5 ft above chart datum. This was 2.5 ft above the recent lake level. The strong northeasterly winds developed waves of 6 to 12 ft from Cleveland west. The winds gusted to 44 kn, and there were waves up to 15 ft on southwestern Lake Michigan. As the storm moved eastward, south of the Lakes, high waves and winds caused flooding along Lake Ontario on the 26th. On the 27th, the storm moved off the coast.

By the end of the month most of the significant ice was in the Gulf of St. Lawrence off the west coast of Newfoundland.

MAY

On May 2, a front stretched southwestward across Lakes Huron and Michigan. On the 1200 chart, a wave was analyzed just north of Chicago. At 1200 on the 3d, this was a 990-mb LOW, centered 300 mi northeast of Lake Huron. Gale-force winds were reported on all the lakes except Erie and Ontario. The highest wind of the month--39 kn--was measured by the J.L. MAUTHE on Lake Superior at 1800 with seas of 15 ft. The LOW continued northeastward and combined with several other LOWs on the 4th.

As the LOW above moved northeastward and the HIGH moved southeastward, a LOW moved toward Lake Superior from Lake Winnipeg. At 0000 on the 5th, the LOW was north of Port Arthur. The ELTON HOYT II was headed north on Lake Michigan with southwesterly gales. At 1800 the SAMUEL MATHER found southerly gales over Lake Huron. Gale warnings were in effect for most of the region. Strong winds caused damage over northern Ohio.

The only other significant weather for the month appeared to be over Lakes Huron and Erie late on the 17th and early on the 18th after the passage of a cold front. The JOHN DYKSTRA and ERNEST T. WEIR both reported light gales.

JUNE

During June there were only three reports of winds with speeds of over 30 kn. They were made by three different ships on three different days all on Lake Superior.

On the 12th at 1800, the CLIFFS VICTORY was off Copper Harbor with southeasterly winds of 31 kn. A LOW was drifting northward near Winnipeg, and a warm front angled southeastward south of the Lakes. The warm front moved over Michigan on the 13th setting off violent thunderstorms during the evening and early morning of the 14th along the eastern shore of Lake Michigan. Gusts to 55 kn were reported at Benton Harbor, Pellston, and Sawyer Air Force Base. Waterspouts and funnel clouds were sighted north and east of Traverse City.

The same instability remained over the Lakes until a cold front swept through on the 16th. It was carried through by a LOW out of the Great Plains that moved northeastward over Duluth. Behind the front, the ELTON HOYT II reported 33-kn westerly winds.

On the 24th, the Great Lakes area was again in the unstable warm sector. Rain and showers were being reported. The ENDERS M. VOORHEES on western Lake Superior measured 45-kn winds from the southwest with moderate, intermittent rain. The Coast Guard station at Toledo, Ohio, reported a waterspout over Lake Erie.

There were strong thunderstorms in the region again on the 30th. No ships reported winds higher than 30 kn. A waterspout was sighted over Lake Michigan off Grand Haven. Three pair were sighted by the Coast Guard 8 to 12 mi north of Grand Marais over Lake Superior. Another was sighted visually and by radar off Dunkirk over Lake Erie.

JULY

This was a continuation of the synoptic condition of June 30. On July 1, a 1002-mb LOW was over Lake Huron. At 0000 the ARMCO was near the center of

Table 14.--Highest 1-min wind (kn) reported on the Great Lakes by U. S. anemometer-equipped vessels

Year	Lake Erie		Lake Huron		Lake Michigan		Lake Superior		Lake Ontario	
1941	W	42	WSW	50	NW	43	NNW	54	--	--
1942	WSW	52	WSW	56	WNW	48	S	62	--	--
1943	WSW	57	WNW	43	SSW	50	WSW	52	--	--
1944	NE	38	NW	37	WSW	48	NNE	42	--	--
1945	WNW	52	SSW	54	WNW	49	NW	52	--	--
1946	SW	50	W	46	S	44	NW	47	--	--
1947	NW	51	SSE	43	ENE	39	WSW	43	--	--
1948	WSW	40	NNW	51	NW	45	WSW	48	--	--
1949	W	52	NNE	50	NNW	43	N	52	--	--
1950	SW	70	NW	48	NW	49	NW	81[1]	--	--
1951	WSW	37	WSW	50	SW	49	WSW	54	--	--
1952	SW	46	SW	57	SSW	44	WSW	45	--	--
1953	WSW	49	NW	45	NNW	46	ENE	50	--	--
1954	W	45	NW	45	E	48	N	43	--	--
1955	W	52	SW	57	WSW	58[1]	NW	48	--	--
1956	WSW	46	W	43	SSW	46	N	50	--	--
1957	WSW	72	SW	54	WSW	49	W	47	--	--
1958	SW	61	SW	43	SW	52	SSW	54	--	--
1959	W	42	NE	50	E	48	W	54	--	--
1960	NE	55	WSW	49	NW	55	N	54	--	--
1961	W	50	NW	47	NW	48	N	57	--	--
1962	NW	52	WNW	63	NW	48	NNW	60	--	--
1963	NNW	74[1]	NW	60	N	52	NNW	52	E	35
1964	WSW	68	W	72	NW	54	WSW	62	WNW	50[1]
1965	WSW	60	WNW	95[1]	ESE	52	SW	70	W	40
1966	ENE	49	NE	60	NW	57	NNE	61	W	39
1967	WSW	43	W	58	ENE	55	N	53	W	32
1968	W	63	NNW	44	WNW	46	NNE	55	SW	31
1969	WSW	44	NNW	46	NW	50	SSW	50	--	--
1970	W	52	W	62	NW	52	W	63	--	--
1971	SW	50	N	53	N	50	SW	56	--	--
1972	W	45	NW	56	N	54	NNE	60	--	--
1973	SW	45	ENE	44	NE	56	NE	50	--	--
1974	ENE	48	SW	47	SW	42	ESE	46	W	38
1975	NE	40	WSW	60	SW	54	W	50	NW	32
1976	W	48	S	56	NNW	55	NE	54	W	34

[1]Highest for each lake

the Lake with the LOW to the south. She measured 48-kn northeasterly winds and 16.5-ft waves. This was the highest wind during the month and one of the four times that 16.5-ft waves were reported. Six hours later the JOHN DYKSTRA had northerly 33-kn winds slightly farther north on the Lake.

On the 7th, a cold front was sweeping southeastward out of Canada. The WILLIS B. BOYER was on western Lake Superior ahead of the front with 36-kn winds. During the afternoon a tornado struck a marina on Lake St. Clair and dissipated as a waterspout. Another waterspout was sighted over the Straits of Mackinac on the 9th. On the 10th, thunderstorms moved off Lake Erie into northeastern Ohio with heavy rains and wind gusts reported up to 87 kn. There was extensive damage to a shipbuilding company in Lorain.

On the 11th, a front lay essentially east-west across the Lakes. Several small waves rippled along the front, and on the 12th one developed into a full grown LOW over the St. Lawrence River. A 1023-mb HIGH was pushing southward from western Hudson Bay, and the front moved southward. There were four reports of gale-force winds on Lakes Erie and Huron. The highest was 46 kn from the northwest on Lake Huron at 1800 by the WILLIS B. BOYER. By the 13th, the LOW had moved eastward and the HIGH southward with corresponding weakening of the gradient.

On the 20th special marine warnings were issued for southern Lakes Michigan and Huron and western Lake Erie for severe thunderstorms.

A severe squall hit Sandusky Bay on the 16th during a sailing race. Of the 40 boats entered, 16 were damaged with broken masts or rudders. One man was drowned. It was estimated that 30 of the lightning class sailing boats capsized, some intentionally as 70-kn winds struck the fleet.

Table 15.--Highest seas reported on the Great Lakes by National Weather Service cooperating vessels, 1976

	Ship	Date	Height (ft)
Lake Ontario	ENDERS M. VOORHEES	November 14	10.0
Lake Erie	JOHN SHERWIN	October 14	16.5
Lake Erie	CHARLES M. WHITE	October 29	16.5
Lake Huron	ARMCO	July 1	16.5
Lake Michigan	SAMUEL MATHER	October 28	14.5
Lake Michigan	ARTHUR M. ANDERSON	December 25	14.5
Lake Superior	PHILIP R. CLARKE	March 7	16.5

Severe thunderstorms struck the southeast corner of Wisconsin late on the 30th. Winds gusted as high as 56 kn. The Coast Guard reported a waterspout over Lake Michigan about 4 mi east-southeast of Milwaukee.

AUGUST

The Bermuda-Azores High had been well established south of Newfoundland for several days and was feeding warm, moist air into the Great Lakes region. A cold HIGH was centered over the western shore of Hudson Bay. A stationary front separated the two air masses from western Lake Superior southward on the 11th. As the front oscillated, it triggered violent thunderstorms on northern Lake Michigan and the surrounding shore. Forty-eight knot winds and 3/8 in hail were reported with heavy rain. Streets were flooded and a school gymnasium roof collapsed from standing water. A waterspout was observed northwest of Leland over Lake Michigan. The JOHN DYKSTRA radioed a special observation at 1515 local time, 10 mi southeast of Whitefish Point, of heavy rain, 45-kn west-northwesterly winds, and building 5-ft waves.

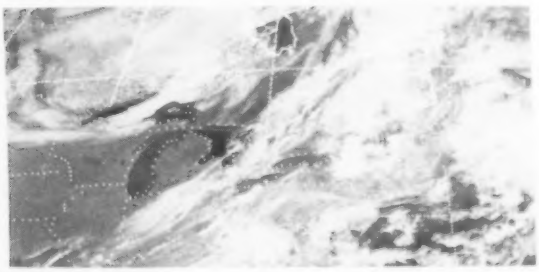


Figure 39.--Late on the 28th the front can be seen moving eastward out of Lake Huron. High winds were associated with this system on Lakes Superior and Huron for several days.

A large, summertime LOW moved eastward across southern Canada late on the 27th and triggered many gale reports on Lakes Superior and Huron through the 29th (fig. 39). Late on the 27th, the cold front moved across Lake Superior. The LOW was 992 mb over James Bay at 0000 on the 28th. The WILLIS B. BOYER was on western Lake Superior at 1800 on the 27th with 46-kn southerly winds east of the front. On the 28th, there were nine reports of winds greater than 30 kn by four ships on Lake Superior. The highest wave was 10 ft. The highest wind was 42 kn with 10-ft waves by the BOYER. On the 29th, there were 10 reports of high winds by seven ships about evenly divided between the two lakes, with 34 kn and 12 ft the highest wind and seas. Among those reporting were the ARTHUR M. ANDERSON, CLIFFS VICTORY, ERNEST R. BREECH, and MIDDLETOWN. The front moved across Lake Ontario and south of Lake Erie on the 29th as a 1030-mb HIGH moved into the basin.

SEPTEMBER

A two-center LOW oriented north-south moved eastward over Canada from the Rocky Mountains on the 1st and 2d. By 1200 on the 3d, the southern center developed into a major storm, just east of Winnipeg. The cold front was near Duluth, and the warm front extended into Michigan. The G.M. HUMPHREY on western Lake Superior had 44-kn southerly winds. The SAMUEL MATHER on central Lake Michigan had 32-kn southerlies and 13-ft waves. Gales were also reported on Lake Huron. Wind gusts of 70 kn were reported at Grays Reef west of the Straits of Mackinac. As the storm passed to the north, no strong winds were observed; but the WILLIS B. BOYER had 42-kn westerlies and 13-ft seas on Lake Huron on the 5th as the HIGH approached.

A front out of a deep LOW in northern Canada was moving across the Great Lakes on the 9th. It stalled over Lake Huron on the 10th as a frontal LOW developed. Gales were reported on Lakes Erie, Huron, and Michigan. At 1200 on the 11th, the J.L. MAUTHE measured 43-kn west-northwesterlies with 10-ft seas on Lake Erie. Sault Ste. Marie set a new high-temperature record of 95° on the 8th, but only reached 57° early in the afternoon of the 9th.

This series of high-wind reports was due to three small LOWs and three fronts passing over the Great Lakes from the 20th through the 24th. The first front passed over the area on the 20th, and a frontal wave developed over Lake Huron. Gales in the low 30's were observed over Lake Michigan. By 1200 on the 21st, another front had moved southeastward and was over Lakes Michigan and Huron. Winds of 46 kn and 12-ft waves were measured on Lake Superior by the J.L. MAUTHE. Lake Michigan had gale reports. On the 21st, a small LOW developed on the front north of Lake Huron and drifted eastward. As a HIGH pushed southeastward, there were gales over Lakes Erie, Huron, and Michigan. Two ships sent out special observations late on the 21st and at 0000 on the 22d. The PAUL H. CARNAHAN spotted seven waterspouts on Lake Erie north of Fairport. The JOHN DYKSTRA also spotted a waterspout north of Ashtabula (fig. 40). Late on the 22d this LOW gained momentum, and another front entered Lake Superior. The JOHN SHERMAN found 42-kn northerlies on Lake Michigan. This system completed the transit of the area late on the 23d. Ships reported gales up to 42 kn which were behind the front on Lake Superior. The CHARLES M. BEEGHLEY braved 45-kn winds and 13-ft seas on Lake Superior. The winds slacked off after the 23d as the area became dominated by a HIGH.

OCTOBER

The first half of the month was quiet on the Lakes. There were a few isolated minimal gale reports. The first storm system that produced a rash of reports followed the passage of a cold front on the 13th and 14th. Winds in the 40-kn category were reported on Lakes Superior and Huron on the 14th, and at 1200 the JOHN SHERWIN was pounded by 16.5-ft waves on

Figure 40.--September spawned a rash of waterspouts on Lake Erie. This spout was sighted near the eastern suburbs of Cleveland. The funnels dissipated quickly on reaching land. Wide World Photo.

central Lake Erie. On the 15th, another system moved over the western lakes. A LOW formed at the occlusion just as the system reached Lake Superior. The ENDERS M. VOORHEES braved 46-kn westerly winds as she sailed westward on Lake Superior. The LEHIGH found 35-kn winds and 12-ft seas on eastern Lake Erie. A lake shore warning was issued for 13-ft waves on the Michigan shore of Lake Michigan. The northwesterly winds created a low-water problem near the mouth of the Detroit River. By the 16th, the LOW was north of Lake Ontario, but the northerly winds still struck ships on Lakes Superior and Huron.

Early on the 21st, a weak LOW was moving southeastward out of Canada across the northern lakes. At the same time a more developed LOW was moving northward along the Atlantic coast. By 1200 the Atlantic LOW had taken over the major circulation as far west as Lake Winnipeg. A trough stretched westward to Lake Superior. Gusts to 60 kn were forecast. On the 22d, winds of 40 kn and above struck Lakes Huron and Erie. Low-water levels were again a problem on western Lake Erie. Gales were reported on Lake Superior.

On the 23d, the LOW was still moving northward with 35-kn westerly winds driving 13-ft waves on Lake Erie at 0000 as recorded by the CHARLES M. WHITE. An early lake-effect snowstorm dropped up to a foot of snow south of Buffalo. Ski resorts opened, and one reported this was the earliest in 20 yr.

A cold HIGH was slowly drifting southward from Manitoba on the 27th. At midday on the 28th, the 1036-mb center was over southern Indiana. A 978-mb LOW center was traveling eastward north of 60°N. The 58-mb pressure difference produced a tight gradient between the two centers with resulting strong winds. On the 28th, gales were blowing over all the lakes. The highest wind measured was 48 kn from the west by the WILLIAM A. REISS near Saginaw Bay. This was also the highest wind of the month. The waves were 10 ft. The BENJAMIN F. FAIRLESS reported 34-kn winds on Lake Ontario. The highest wave that day was 15 ft on northern Lake Michigan.

By 1200 on the 29th, the 1032-mb HIGH center had drifted into Kentucky, and the 975-mb LOW was east of Hudson Bay near 58°N, 70°W. The front lay across northern Lake Superior. The winds had decreased slightly, and the strongest logged on the 72-2 was 37 kn on Lake Erie by the CHARLES M. WHITE at 0600. At 1200 her waves were 16.5 ft (fig. 41). On the 30th, the two continued their individual movements, and the pressure gradient relaxed.

Figure 41.--High winds and waves occurred in fair weather. Note the clouds on the lee side of the Lakes.

NOVEMBER

On the 2d, a LOW moved southeastward along the southwestern shore of Hudson Bay, and the attendant front was over the Lakes. The winds mostly affected Lake Superior. The PHILIP R. CLARKE found 40-kn gales twice on the 3d as she approached Duluth. On the 4th, the LOW moved southward across the Lakes, but it was rapidly weakening. The ELTON HOYT II braved 31-kn northwesterly winds north of Chicago, and there was a 32-kn report on Lake Superior.

On the 7th and 8th, there was a deep LOW centered on the Labrador coast and a cold HIGH centered near Omaha, Neb. For a short period late on the 7th and early on the 8th, there was a strong northwesterly flow across the Lakes. The G. M. HUMPHREY measured 44-kn winds with 10-ft waves near Whitefish Bay. There was a 32-kn gale report on eastern Lake Erie.

This was another one of those situations where the Great Lakes Basin was squeezed between a LOW to the

Figure 42.--This is an example of the damage and shore erosion that can occur from high waves pounding the shoreline.

north and a cold, slow-moving HIGH to the west and south. On the 13th, the LOW was traveling southeastward over Hudson Bay from the Beaufort Sea. The cold HIGH was drifting down the Missouri River Valley. On the 13th, most of the gale reports were over Lake Superior with the exception of a 32-kn observation on northern Lake Huron by the THOMAS WILSON. At 1930 the LEON FALK JR sent a special observation of 45-kn winds and 20-ft waves 10 mi north of Copper Harbor. On the 14th both the LOW and HIGH had taken an easterly track and the high winds spread to Lakes Michigan and Huron. Gale warnings were up for all lakes except western Lake Superior. Winds over 40 kn were pushing waves of 8 to 15 ft, resulting in lake shore warnings for Lake Ontario. The highest winds of 45 kn accompanied by 15-ft waves were measured on eastern Lake Superior early in the day by the WILLIAM A. IRVIN. After midday the winds and waves decreased in intensity.

A deep LOW moved northward out of the Atlantic and was centered over the Gulf of St. Lawrence on the 21st. At this time a long, narrow high-pressure ridge started drifting eastward from the Rocky Mountains. The LOW stalled over southwestern Labrador on the 22d as the ridge pushed eastward. Gale reports in the high 30's were common on Lakes Superior and Huron. The JOHN SHERWIN had 37-kn northwesterly winds blowing 13-ft waves on northern Lake Huron. The air temperatures were below freezing.

On the 23d the ridge split with the predominant center over Mississippi. The winds remained in the gale category and were reported on all except Lakes Erie and Ontario. All the Lakes were covered by wind and shore warnings. Waves up to 10 ft were predicted on Lake Michigan and 12 ft on Lake Ontario (fig. 42). Small amounts of ice accumulation on ships were now being reported. On the 24th, an ice watch was issued for the rapid formation of ice with another cold air outbreak.

A large, irregularly shaped HIGH centered over the Pacific Northwest covered the western two thirds of the United States on the 27th. A front with waves stretched from Houston to Maine. At 1200 on the 27th, a wave was centered north of Detroit, and there were gale reports on Lake Michigan. By 1200 on the 28th, the front paralleled the Appalachian Mountains and the HIGH spread eastward. Cold air was streaming down over the Lakes from Canada. There was a report of minus 13°C on Lake Superior by the ENDERS M. VOORHEES with 38-kn winds. Gales and cold air also covered Lakes Michigan and Huron. On the 29th and 30th this cold air spread to Lake Erie. Duluth Harbor was already 80-percent covered by ice 6 in thick and increasing. Also, the westerly winds had lowered the water level on western Lake Erie. The strongest wind of the month--46 kn--was measured by the G. M. HUMPHREY over central Lake Erie on the 30th. Isolated gales continued into December.

DECEMBER

A stationary front stretched between Alaska and Arkansas on the 1st separating continental and maritime air masses. A LOW developed at the southern end and started traveling toward the Great Lakes. The three western lakes all experienced gales. The LOW moved north of the Lakes on the 2d drawing even colder air over them behind the cold front. The BENJAMIN F. FAIRLESS found 12-ft waves and 32-kn

Figure 43.--The St. Joseph North Pierhead Light on Lake Michigan in 1964 when similar high winds and cold temperatures coated it with ice.

northerly winds at minus 25°C on Lake Huron (fig. 43). The G.M. HUMPHREY had sailed to Lake Superior and again measured the strongest wind of the month of 46 kn. On the 3d, high pressure moved in.

On the 9th, there was high pressure over the eastern third of the nation and isolated gale reports. On the 10th, a LOW was over Whitefish Bay. Winds over 30 kn were measured on Lakes Erie, Michigan, and Superior. The LOW picked up speed as it moved across the Lakes and by 1200 on the 11th was over the Gulf of St. Lawrence. Gales to 40 kn were blowing on Lake Superior as the PHILIP R. CLARKE reported. The THOMAS WILSON measured only 32 kn, but the waves were 15 ft near the center of the Lake.

This storm formed over the Canadian Rocky Mountains in conjunction with a short wave in strong zonal flow aloft. It raced southeastward and was north of Lake Superior at 1200 on the 14th. It brought strong winds and high waves to the Lakes. The CASON J. CALLAWAY had 45-kn westerlies and 10-ft seas on western Lake Superior. The SAMUEL MATHER also had 45 kn on Lake Huron. Lake Michigan was included with 42-kn winds and 12-ft waves as measured by the ARTHUR M. ANDERSON. The G.M. HUMPHREY radioed a 0725 special observation from 28 mi east-northeast of Outer Island of 54-kn winds from the south-southwest and 12-ft waves. The storm took one last swipe at Lake Superior at 0000 on the 15th, raising 13-ft waves to slap the WILLIAM A. REISS. By 1200 a bubble HIGH was over the area.

This storm formed on the 19th as a frontal wave over Iowa and developed quickly. By 1200 on the 20th, it was 994 mb just north of Lake Erie. It was bringing winds of over 40 kn to Lake Michigan and gales to Lake Superior. The ENDERS M. VOORHEES measured 42 kn on northern Lake Michigan. The low center moved to Maine by 1200 on the 21st bringing cold northwesterly flow across all the lakes making winter official. Gale warnings covered all the lakes except Lake Superior. There was a shore warning for Lake Erie. On the 22d, gales were still blowing as the storm moved over the Gulf of St. Lawrence.

Several stations including Sault Ste. Marie reported this as the coldest December on record.

ACKNOWLEDGMENTS

An expression of appreciation is extended to the masters and mates aboard the Great Lakes cooperating vessels for their valuable observations and contributions to the National Weather Service observing program. Much useful information and photographs were obtained through the courtesy of Albert G. Ballert and the Great Lakes Newsletter of the Great Lakes Commission. National Weather Service meteorological and ice data were provided by Daron E. Boyce of the Ice Navigation Center.

Of primary importance were the listings of wind, wave, visibility, ice, and special observations prepared by John Snelling of the Applied Climatology Branch of the National Climatic Center on which most of the specific information in this article is based.

WE OF NOAA ARE MAKING USE OF THIS SMALL AMOUNT OF SPACE TO EXTEND OUR THANKS TO ALL THE SHIPS' OFFICERS WHO ROUTINELY TAKE SHIPBOARD WEATHER OBSERVATIONS. TO US THESE EXCELLENT OBSERVATIONS ARE PRICELESS. WE CERTAINLY DO APPRECIATE RECEIVING THEM ON A REGULAR BASIS.

Hints to the Observer

HURRICANE REPORTING

Dear Captain:

I'd like to remind you that the hurricane season (June through November) is near. In order for us to provide adequate warnings, it is essential that we receive as much information as possible from ships encountering evidence of hurricanes.

To assist our forecasters in determining storm location, intensity, and movement, we would like you to:

1. Make and transmit reports at least at 3-hr intervals when within 300 mi of a tropical storm or hurricane.

2. Include in "Remarks" the lowest pressure and/or the highest wind encountered if, since the last synoptic report:

   a. The pressure was more than 5 mb lower, and/or

   b. The wind was more than 15 kn higher than the present value(s).

   Also, include the time of occurrence.

   Example: 0800Z LOWEST PRESSURE 970MB 0730Z HIGHEST WIND 85KN.

I've enclosed copies of "General Instructions for Radio Reporting of Weather Observations" for your use.

The National Weather Service appreciates the time and effort you and your officers give to provide reports of weather conditions at sea. Your reports are extremely important considering the vast ocean spaces and the relatively few ships that report weather.

Sincerely,

George P. Cressman

George P. Cressman
Director, National Weather Service

GENERAL INSTRUCTIONS FOR RADIO REPORTING OF WEATHER OBSERVATIONS

Standard Synoptic Observation Times--The regular weather-reporting hours are 0000, 0600, 1200, and 1800 GMT. Occasionally, watch schedules or priority of other duties make it impractical to make and transmit surface observations at standard synoptic times. To ensure message transmission, observations may be made in advance of the weather-reporting hours. In these cases, the actual time of observation should be included in the report.

Coded Weather Messages--All messages to be transmitted by radio should be transcribed from the ship's weather log to NOAA Form 72-4, "Weather Report for Immediate Radio Transmission," in the ship synoptic code FM21V or FM23V and given to the Radio Officer.

Transmission of Radio Messages--Weather messages should be transmitted as soon as possible to the most convenient radio station in accordance with instructions contained in United States and Foreign Coastal Radio Stations Accepting Ships' Weather Observation Messages.

Weather Message Addresses for Transmission to U.S. Radio Stations--Use "OBS METEO WASHDC" when in the:

1. Western North Atlantic, including the Gulf of Mexico and Caribbean Sea, north of 3°N latitude, and west of 35°W longitude (WMO Region IV-A).
2. Eastern North Pacific (north of the Equator), east of the 180th meridian (WMO Region IV-A).
3. Eastern South Pacific (south of the Equator), from the South American coast to 120°W longitude (WMO Region III-B).

Use "OBS METEO GUAM" when in the western North Pacific between 5° and 25°N latitude, and from 135°E to the 180th meridian (WMO GUAM ZONE).

Observations During Storm Conditions--Whenever TROPICAL STORM, TYPHOON, or HURRICANE conditions are encountered anywhere, "SAFETY OF LIFE AT SEA CONVENTION," Chapter V, requires all ships to take a special observation and transmit the report to the closest national meteorological service via the most convenient radio station. In addition to this requirement, it is highly desirable that weather reports be transmitted hourly if possible, but, in any case, not less frequently than every 3 hr.

Special Requests for Observations--During storm situations, the U. S. National Weather Service may request ships located in areas of suspected storm development to take special observations at more frequent intervals than the routine 6-hr synoptic observation times. If your ship happens to be in such an area, your report will be helpful even though conditions may not appear bad enough to warrant a special observation. To speed delivery of messages from storm areas and to identify them as such, the word STORM should appear immediately following the radio address. These messages should be addressed to the requesting forecast office. For example, "OBS METEO NEW YORK STORM 99305 70750," etc., would

be used if the New York Forecast Office requested the observation.

The National Hurricane Center (NHC) has had trouble in the past getting responses to their occasional requests for special weather reports during hurricane alerts. We would like your ideas on how to increase ship response to these special requests. Please address your comments to:

Mr. Robert Schoner, W521x2
Marine Program Leader
National Weather Service, NOAA
Silver Spring, MD 20910

Observations in Coastal Waters--Since radio weather reports are always needed from ships in coastal waters, observations should continue to be taken as close to shore as ship routine permits.

Tips to the Radio Officer

Thomas H. Reppert
National Weather Service, NOAA
Silver Spring, Md.

The National Weather Service (NWS) has expanded the marine weather broadcast capability in Alaska with the addition of four VHF-FM stations. This brings the total in operation to six, with five others planned. The single-sideband stations operated by the NWS have revised their schedules; and Annette, Yakutat, and Cold Bay have added an additional frequency. The summary of Alaskan voice marine weather broadcasts shown in figure 44 is available on a 4- by 5-in card from the National Weather Service, Communications, 632 6th Avenue, Anchorage, AK 99501.

NWS STATIONS	2383.4 KHz	4136.3 KHz
Annette	1000 2200	0200 1500
Juneau	0600 1900	
Yakutat	0900 2100	0300 1600
Kodiak		0400 1800
King Salmon	0215 2015*	
Cold Bay	0500**1700**	0800 2200
RCA STATIONS	2313.4 KHz	2401.4 KHz
Ketchikan	0230 0430 1430 1630 2100	
Sitka		0230 0430 1430 1630 2100
Juneau		0230 0430 1430 1630 2100

COAST GUARD STATIONS	2671.4 KHz	
Ketchikan	0315	1515
Juneau	0300	1500
Biorka	0800 2000	1250 2330
Ocean Cape	0145 1345	0845 2045
Middleton Is	0200	1645
Kodiak***	0200	1645
Cape Sarichef	0515 1715	1310 0015
Adak	0530 1730	1340 0030
Attu	0545 1745	1350 0045

Due to the 2182 KHz silent period, broadcasts on hour and half hour will be delayed 3 minutes. Times may change without notice.
To convert GMT to Local Standard Time, subtract for PST 8, YST 9, AST 10, BST 11 hours. For Daylight Saving Time subtract one hour less. All frequencies are Upper Sideband.
*Seasonal May 1 to Oct. 15 **2513.4 KHz ***Also 6523.2 KHz

VHF-FM MARINE AND LOCAL WEATHER BROADCASTS ALASKA
Scheduled Broadcasts Are In GMT Time

NWS STATIONS 162.55 MHz Continuous Broadcast		
Anchorage	Cordova*	Juneau
Ketchikan	Kodiak*	Petersburg*
Seward	Sitka*	Valdez
	Yakutat*	
162.4 MHz Continuous Broadcast		
	Homer	Wrangell*
RCA STATIONS 162.0 MHz at 0230 0430 1430 1630 2100		
Juneau	Ketchikan	Petersburg
	Sitka	

COAST GUARD STATIONS Channel 22 Marine Weather		
Gravina Is	0315	1515
Zarembo	0215	1415
Cape Decision	0115	1315
Biorka	0800 2000	1250 2330
Mud Bay (Sitka)	0100	1300
Cape Fanshaw	0200	1400
Robert Baron (Admiralty Is)	0300	1500
Pillar Mt (Kodiak)	0030	1330

*Under Construction

Figure 44.--Schedule of Marine Weather Broadcasts Alaska. All times are GMT.

Hurricane Alley

Dick DeAngelis
Environmental Data Service, NOAA
Washington, D. C.

Ten Southern Hemisphere tropical cyclones reached either tropical storm or hurricane strength during January and February. This is slightly less active than normal during the heart of the season when about 13 to 15 storms are expected. The North Indian Ocean was quiet and this is not unusual. Tracks of the tropical cyclones are shown in figures 45 and 46.

SOUTH INDIAN OCEAN - JANUARY AND FEBRUARY

Two hurricanes with maximum winds estimated at 135 kn plagued these waters during the 2-mo period. The first of these was born on the 1st day of the new year. Moving west-southwestward, it developed quickly. By the 5th winds were hurricane force, and the following day they climbed past the 100-kn mark.

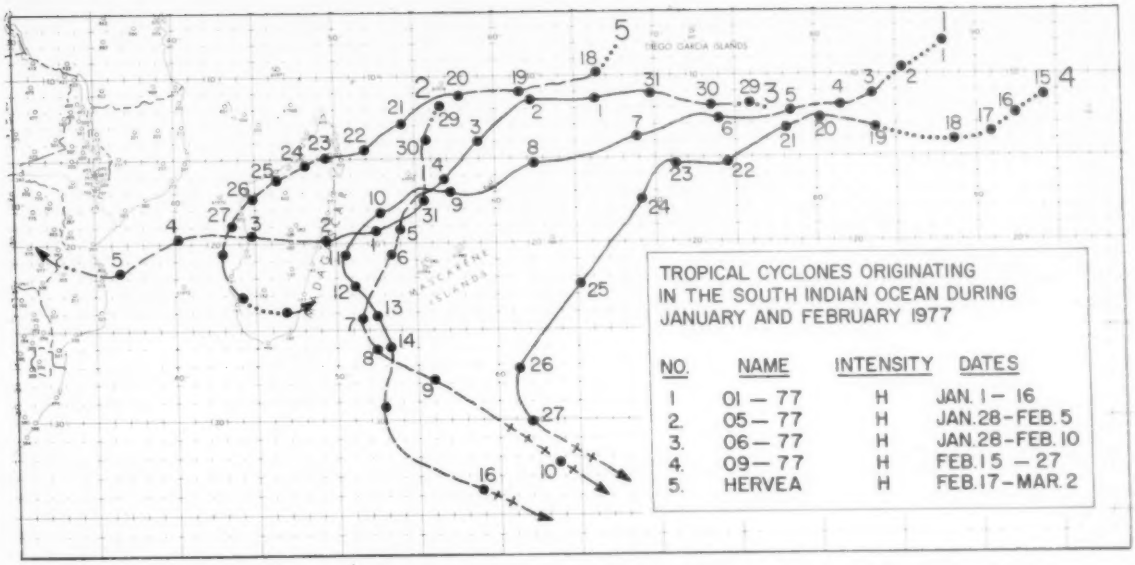


Figure 45.--Tracks of tropical cyclones in the South Indian Ocean, January and February 1977.

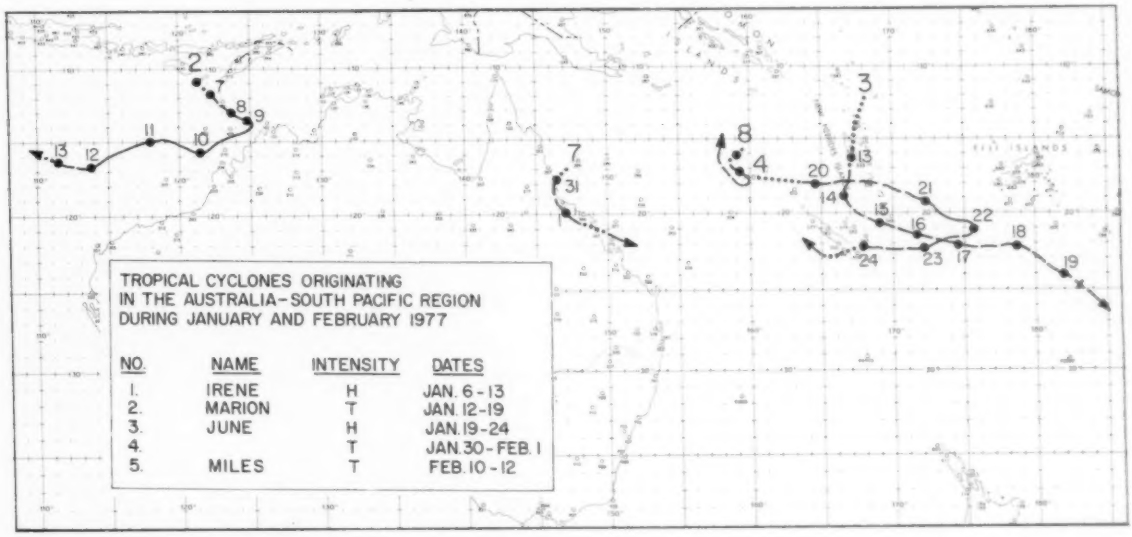


Figure 46.--Tracks of tropical cyclones in the Australia-South Pacific area, January and February 1977.

Figure 47.--Shortly after crossing St. Brandon on the 8th, this 135-kn hurricane was caught along the 15th parallel by the NOAA satellite cameras.

The storm's course took it right across St. Brandon (fig. 47). At 1200 on the 8th, the island reported 60-kn southeasterlies in heavy rain. Top winds in the storm occurred late on the 9th and early on the 10th. At this time the severe hurricane was beginning to recurve before hitting the Malagasy Republic.

These tropical waters remained quiet until the end of the month when two hurricanes developed about 1,000 mi apart. Both were detected by satellite in their infancy along the 7th parallel. Both reached hurricane strength on the 31st. The more westerly of the two was turning westward toward the Malagasy

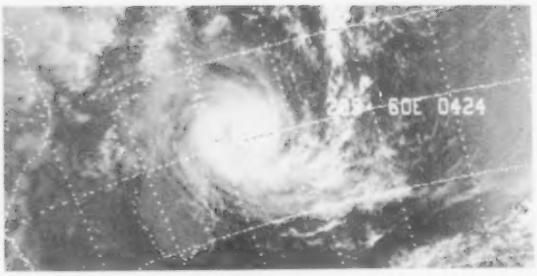


Figure 48.--Twin hurricanes pose a threat to the Malagasy Republic on the 1st of February.

Republic, while the other was on a westerly course far to the northeast (fig. 48). The former storm was generating 90-kn winds as it came ashore near Mahanoro on the 2d. Crossing the island and the Mozambique Channel as a tropical storm, it finally moved onto the African coast near Mambone, Mozambique, on the 5th. Meanwhile, the latter storm had developed maximum winds of 70 to 75 kn, which were sustained until the 4th, when the storm recurved between the Mascarene Islands and Madagascar on its way to an extratropical finale.

Another pair of hurricanes reared up in mid-February. The first was spotted on the 15th just northwest of the Cocos Islands. The westward-moving system took 4 days to reach hurricane strength. By this time another storm, Hervea, was detected just west of Diego Garcia. She reached hurricane intensity just southwest of Agalega Island on the 20th. Maximum winds climbed to 100 kn before Hervea moved ashore over the Malagasy Republic near Antalaha on the 22d (fig. 49). The first storm was even more severe. Maximum winds near the center were estimated at 135 kn on the 23d and 24th as it recurved to the east of the island groups. It remained intense until it crossed the 30th parallel on the 27th. It was about this time that the Madagascar storm, which had crossed the island at tropical storm strength, made a brief appearance over the Mozambique Channel before recurving into a southern Madagascar graveyard.

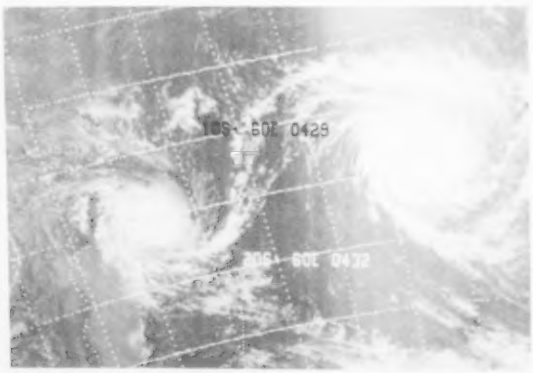


Figure 49.--Almost an instant replay of 3 weeks before, two hurricanes threaten the Malagasy Republic on the 22d.

Figure 50.--Irene develops as she moves toward northwestern Australia on the 7th.

AUSTRALIA-SOUTH PACIFIC REGION
JANUARY AND FEBRUARY

This area saw an unbroken string of tropical cyclone days from the 6th through the 24th. Irene started it off on the 6th just off the Sumba coast. She headed toward northwestern Australia (fig. 50) but turned westward about 100 mi west of Kalumburu on the 9th. By this time Irene was a hurricane, generating maximum winds of 100 kn. This intensity lasted from the 8th through the 11th. As she began to dissipate, Marion was coming to life among the New Hebrides. She was never more than a tropical storm although maximum winds were estimated at 60 kn on the 15th and 16th. While Marion was turning extratropical on the 19th, June was developing in the seas west of the New Hebrides. June moved eastward (fig. 51) and reached hurricane strength on the 21st after crossing through the New Hebrides. Maximum winds climbed to 70 kn.

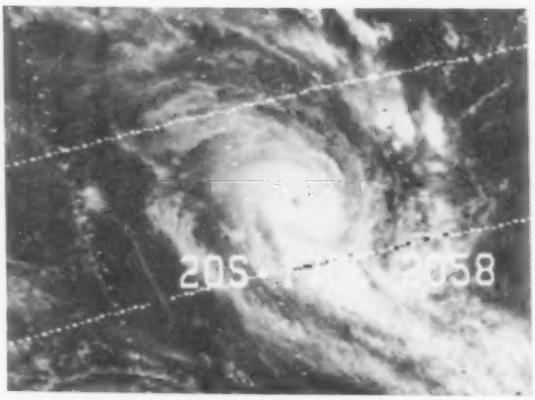


Figure 51.--June in January (on the 20th).

Toward the end of the month, a short-lived tropical storm popped up off the northeast Queensland coast about 60 mi east of Cairns. While it was too close to land to really develop, winds did reach 35 kn as it skimmed along the shore. Another short-lived storm, Miles, came to life in February. He developed in the Coral Sea on the 10th, and maximum winds reached 40 kn before he died on the 12th.

SOUTH PACIFIC - DECEMBER 1976

Two small, but potent tropical cyclones almost

slipped through the observational grid. Thanks to Tom Tatekawa at Pago Pago and Paul Haraguchi at the Forecast Office in Honolulu, we now have a record of these systems.

About a week after the development of a surface trough in the tropical central South Pacific, tropical storm Kim was spawned south of the Ellice Islands on the 8th. Moving east-southeastward, Kim passed a few miles south of Tutuila Island on the 10th. Meanwhile, Laurie had come to life on the 9th close to where Kim was first spotted. Laurie followed a similar track which took her just north of Tutuila Island on the 11th. Of the two storms, Laurie was the more intense. From the reports of the two stations on Tutuila (table 16), it appears that Laurie reached hurricane strength as winds gusted to 91 kn and a pressure of 973 mb was recorded.

Table 16.--Tropical cyclone data, tropical storms Kim and Laurie, December 1976

Station	Date	Pressure (in) Low	Time (LST)	Wind (mi/h) Fastest mi	Time (LST)	Gusts	Time (LST)	Storm Rainfall (in)
Tutuila Island								
Pago Pago (WSO)	10	29.30	0010			NW 59	0026	4.67
Cape Matatula	10	29.04	0020					
Pago Pago (WSO)	11	29.26	0200	NW 52	0230	59	0230	
Cape Matatula	11	28.73	0215			105	0130	

NAMES FOR TROPICAL CYCLONES, 1977

The following lists of names are those that will be assigned to tropical cyclones that reach tropical storm or greater intensity during calendar year 1977. A new list is started each calendar year for tropical cyclones of the eastern North Pacific (Central American west coast to 140°W) and of the North Atlantic, including the Caribbean Sea and the Gulf of Mexico. For the western North Pacific (140°W to the Asiatic mainland), the practice of continuing the alphabet from the previous year remains unchanged.

Atlantic	Eastern Pacific	Western Pacific	
Anita	Ava	Patsy	Polly
Babe	Bernice	Ruth	Rose
Clara	Claudia	Sarah	Shirley
Dorothy	Doreen	Thelma	Trix
Evelyn	Emily	Vera	Virginia
Frieda	Florence	Wanda	Wendy
Grace	Glenda	Amy	Agnes
Hannah	Heather	Babe	Bess
Ida	Irah	Carla	Carmen
Jodie	Jennifer	Dinah	Della
Kristina	Katherine	Emma	Elaine
Lois	Lillian	Freda	Faye
Mary	Mona	Gilda	Gloria
Nora	Natalie	Harriet	Hester
Odel	Odessa	Ivy	Irma
Penny	Prudence	Jean	Judy
Raquel	Roslyn	Kim	Kit
Sophia	Sylvia	Lucy	Lola
Trudy	Tillie	Mary	Mamie
Virginia	Victoria	Nadine	Nina
Willene	Wallie	Olive	Ora

On the Editor's Desk

NOAA-NAVY ESTABLISH JOINT ICE FORECASTING CENTER

The U.S. Navy and NOAA are establishing a Joint Ice Center for forecasting and reporting ice formations in the waters of the Northern Hemisphere. To meet an expected increase in the need for ice information as resources of the Alaskan area are further developed, the two agencies will pool existing activities and will be located at the Navy's Fleet Weather Facility in Suitland, Md.

The Joint Ice Center will provide ice forecasts and advisories to support activities of the Department of Defense and also will provide advisories and guidance to NOAA's National Weather Service. The NWS forecast office in Fairbanks, Alaska, will prepare ice forecasts for Alaskan area waters. Two other elements of NOAA, the National Environmental Satellite Service and Environmental Research Laboratories, will also contribute to the center.

The satellite arm of NOAA will make available ice pictures and interpretation from its polar-orbiting satellite system, while the Pacific Marine Environmental Laboratory in Seattle, Wash., will develop improved short-range (3- to 5-day) forecasts through numerical modeling and long-range ice "foreshadowing" through climatological studies.

Supporting studies of ice dynamics will be done under contract to the Seattle laboratory by AIDJEX, the National Science Foundation-Office of Naval Research Arctic Ice Dynamics Joint Experiment.

The Navy, which has conducted research into ice formation and movements for several decades, will perform aerial ice reconnaissance from both Navy and civil aircraft flying over the Arctic ice fields.

Research and development activities in the past by the Navy have established a solid foundation of knowledge about ocean ice phenomena, contributing significantly to the quality and reliability of ice forecasting.

TANKER GULF STREAM USE SAVES FUEL

Oceangoing vessels taking advantage of the swift currents of the Gulf Stream have realized significant fuel savings, according to a study conducted by Exxon Company, USA, in cooperation with NOAA.

As a result of the study, all Exxon vessels sailing the Gulf of Mexico and the Atlantic Seaboard today are routinely using Gulf Stream data, with a potential annual fuel savings of about a third of a million dollars.

The Exxon study, carried out by its Marine Department, relied upon analysis of NOAA satellite pictures to determine the ever-shifting location of the Gulf Stream and particularly its western boundary, known as the "Western Wall." The most rapid currents in the Gulf Stream are found about 12 to 15 mi (19 to 24 km) east of the western boundary, generally moving northward as much as 4 kn faster than waters on either side.

During 1975 six of Exxon's fleet of tankers carrying oil from ports in the Gulf of Mexico to terminals along the East Coast intentionally used the Gulf Stream to hasten their northbound passage, and avoided it when southbound. Masters of the ships plotted their courses in relation to NOAA-determined Gulf Stream

positions as transmitted to them via an RCA radio facility in Port Arthur, Tex.

At the same time, five sister ships continued their normal navigating practices, without benefit of the satellite-derived Gulf Stream information. The masters of the "control" vessels were experienced Gulf Stream navigators and plotted their courses based on general knowledge of the Stream through long experience, published information, and personal knowledge.

The test revealed a total fuel savings of 12,500 barrels (525,000 gal) by the six full-time participants, and 3,500 barrels (147,000 gal) saved by an additional five vessels which participated during the last 4 mo of the year.

A simplified practical method using the satellite data has been developed for routine fleet use and is now in practice throughout the Exxon fleet. Exxon estimates the potential fuel savings for the entire fleet in 1976 will be 31,500 barrels (1,323,000 gal) or about $360,000.

Until 1972, when accurate satellite observation of the Gulf Stream first became possible, the method used by sailors for navigating the Stream was based on personal experience of the master and published guidance materials such as Coast Pilots, current charts, and Sailing Directions. It was assumed that this procedure resulted in successful utilization of the Gulf Stream; however, comparison of 20 such transits with satellite-aided voyages showed that only 11 proved to be successful, four marginal, and five poor.

NOAA's environmental monitoring satellites have the capability of determining water surface temperatures with infrared sensors. Computers at NOAA's National Environmental Satellite Service in Suitland, Md., receive this information from the spacecraft and, by assigning varying shades of grey to different sea surface temperatures, provide special marine enhanced imagery.

The Western Wall of the Gulf Stream usually can be seen in the satellite imagery on cloud-free days because of the great temperature differential between waters within and outside of that part of the Stream. The Gulf Stream is most easily recognized from space during the winter when there is a large temperature differential and least recognized in the summer.

During 1975 the satellite-observed position of the Western Wall varied as much as 130 mi (209 km) at latitude 32.5°N, and thus its fastest currents were seldom stationary. With a complex pattern of meanders as much as 250 mi wide, the Stream position requires constant updating if mariners are to either use or avoid the fast-flowing currents.

Three times each week, NOAA oceanographers analyze satellite pictures to determine the location of the Western Wall and provide the analysis to two Coast Guard radio stations on the East Coast for rebroadcast to ships at sea. The messages are sent by voice transmission and Morse code from Portsmouth, Va., and by Morse code from Miami, Fla.

Using these broadcasts, Exxon masters plot courses which allow them to use the current in traveling northward or up the Atlantic coast, and to avoid the current's slowing effect going down the coast.

The effectiveness of the NOAA Gulf Stream service was demonstrated by comparing the average miles per round trip travelled by ships using the information and those not using it. Distance savings were translated into fuel savings.

Ships' masters used the Gulf Stream currents on northbound trips by plotting a course that would keep them within the general flow of the Stream until they felt its added speed no longer compensated for the departure from a straight-line course. On southbound voyages, the ships stayed either to the west or at least 60 mi (96 km) east of the Western Wall to avoid, as much as possible, bucking the northerly flowing current.

PUBLIC SERVICE AWARDS

The following five ships were presented Public Service Awards by the Director, National Weather Service, Southern Region, for the outstanding cooperation of the Master and officers in taking and transmitting marine weather observations:

DAVID P. REYNOLDS
INGER
J. LOUIS
LOUISE
RICHARD

A sample copy of the letter which accompanied the award is shown below.

National Weather Service
Southern Region
819 Taylor, Room 10E09
Fort Worth, TX 76102

Dear Captain:

The cooperation of you and your officers in the taking and transmitting of marine weather observations is outstanding. The observations you regularly provide enable the National Weather Service to better forecast weather in the Gulf of Mexico and Western Caribbean.

On behalf of the National Weather Service, I am pleased to present a Public Service Award in recognition of the services you have rendered to the maritime community as well as to us.

If the Weather Service can be of any assistance to you, contact Mr. Julius Soileau, our Port Meteorological Officer at Houston.

Sincerely,

Harry P. Foltz
Director, Southern Region

NOAA, MARAD ISSUE REPORT ON HYDROCARBONS

The first comprehensive survey of existing hydrocarbons in the global ocean shows small quantities of these compounds everywhere, with faint trails of higher concentrations along major routes followed by oil tankers.

The study by NOAA, the U.S. Maritime Administration (MARAD), and Exxon Corporation measured the amounts of hydrocarbons currently present in ocean waters. This knowledge of present-day distributions of hydrocarbons, which can come from a variety of sources besides petroleum, provides a baseline against which future environmental changes can be detected and evaluated.

A final report of the study has been published by MARAD and NOAA's Marine Ecosystems Analysis

Program, both agencies of the Department of Commerce. The report concludes that though hydrocarbon levels vary greatly from place to place, most measurements in the upper water levels are in the range of 1 to 10 parts per billion. In deeper ocean waters, hydrocarbon levels are lower, often less than 1 part per billion. Coastal and harbor waters and open ocean waters frequented by tanker traffic have higher concentrations of hydrocarbons than the open ocean off major routes.

For the study, water samples were collected from Exxon tankers travelling on such routes as New York to the Gulf of Mexico and the Persian Gulf to Europe and from research vessels associated with the National Science Foundation in the Atlantic and Pacific. The researchers also culled hydrocarbon measurements from reports of research conducted by many other scientists.

Some of the samples were analyzed to determine the chemical types and possible origins of hydrocarbons. The researchers found that cycloparaffins were the dominant type everywhere. Since cycloparaffins have not been reported as being ubiquitous in marine organisms, their presence would tend to suggest a petroleum source.

The National Academy of Sciences estimates that six million metric tons of hydrocarbons enter the sea each year. About 35 percent of this can be attributed to leakage incident to the marine transportation of petroleum. River runoff adds 26 percent. Natural seeps and the atmosphere contribute 10 percent each; nonrefining industrial wastes, urban runoff, and municipal wastes total 15 percent; coastal refineries and offshore oil production 4 percent. Organisms in the sea also produce hydrocarbons, but of a chemical type different from petroleum.

Experiments on petroleum's effects on marine life usually involve much higher concentrations than were found, but petroleum hydrocarbons at levels near those found at some places in the oceans can affect behavioral traits of certain organisms. The researchers suggest that studies focus on the effects and risks associated with present and possible future levels of hydrocarbons in the oceans.

The report includes maps showing the locations where water samples were collected and the average hydrocarbon levels in different regions, graphs of relative frequencies of hydrocarbon concentrations along tanker and research ship routes, and profiles of hydrocarbon types at different depths. The report, "Hydrocarbons in the Ocean," is available from the Marine Ecosystems Analysis Program, NOAA, ERL, Boulder, CO 80302.

METRIC UNITS, NEW COLORS USED ON LAKE ERIE PROTOTYPE CHART

Major changes in the design of a prototype nautical chart, including for the first time the use of new colors and metric units of measurement, have been announced by NOAA.

Produced by the National Ocean Survey, the new chart of Lake Erie is the result of a cooperative effort between NOS and Canadian charting authorities to standardize nautical information as much as possible. The new chart reflects recommendations from various user groups and other international charting authorities and will serve as a prototype for future nautical charts throughout the United States.

The conventional side of the Lake Erie chart retains the traditional ft/fathom units, the regular color designations for land and water, and the diamond-shaped buoy symbols. The metric side has incorporated the following changes:

1. Metric units of measurement.
2. Mercator projection. This change affects only the Great Lakes charts since charts of other areas are already on this projection.
3. New colors for land and inshore areas. Intended to improve chart definition at night under "red light" illumination, the Lake Erie chart changes the printing colors for water and land from a yellow and a light blue to a gold and a green-blue.
4. Use of more depth contours and fewer individual soundings.
5. International buoy symbols.

Production of the new Lake Erie chart was coordinated with a similar chart of Lake Ontario being issued simultaneously by the Canadian Hydrographic Service.

Cartographers of the two countries achieved significant compatability in specifications for the two charts, which will enable the National Ocean Survey to reproduce the Canadian chart of Lake Ontario directly from reproduction negatives after minor changes. Canadian authorities will also be issuing the Lake Erie chart made by the United States.

Canada and the United States have cooperated in marine surveys and the charting of coastal and inland navigation routes of mutual interest for many years. A joint advisory committee was set up in 1963 to assess the complex technical problems involved in reducing duplication of effort and in preparing common standards of presentation and procedure.

The two countries exchange their plans for field surveys twice yearly, resulting in a number of cooperative operations. Survey results are also exchanged.

In addition to the economies achieved by the cooperative plan, the move is welcomed by ships' navigators who will be able to interchange U.S. and Canadian charts along a route and find a large degree of uniformity in the charts.

The cooperative charting scheme will be extended to other areas of the Great Lakes and coastal areas of mutual interest in the future.

Copies of the Lake Erie chart--Number 14820 (formerly LS3)--will be furnished to all nautical chart sales agents and to user groups and associations for display and examination. Groups which do not receive a copy may request one from the NOS Distribution Division (C44), Riverdale, Md. 20840. Comments should be sent to: Director, National Ocean Survey, Rockville, Md. 20852. Attn: C32.

SCIENTISTS MEASURE CURRENTS UNDER BERING SEA ICE

NOAA scientists are taking the first systematic look at how ocean water moves beneath the Bering Sea ice pack.

The unique measurements being made by submerged current meters are part of a sub-Arctic study by oceanographers with the Pacific Marine Environ-

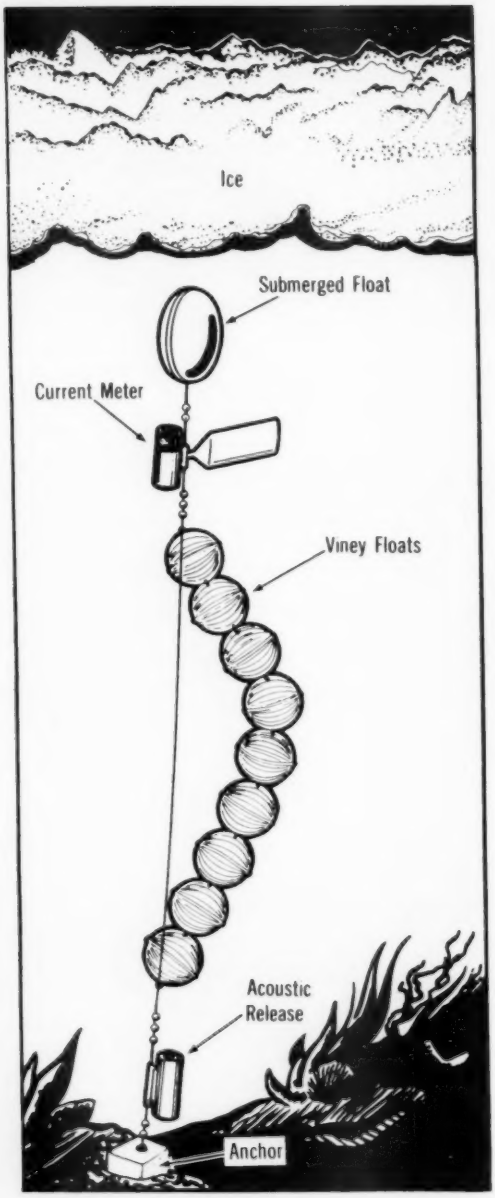


Figure 52.--Configuration of submerged current meter.

mental Laboratory in Seattle, one of NOAA's Environmental Research Laboratories, and with the University of Washington.

What they learn will be applied in a major environmental study managed by the Environmental Research Laboratories for the Interior Department's Bureau of Land Management, in an effort to establish environmental baselines, and to predict the primary impact of petroleum development off Alaska. Little is known of water movement beneath the northern ice pack--or how water would transport oil spilled into the sub-Arctic marine environment.

It is known that the water is driven by a large pressure gradient from the Bering Sea northward through the Bering Strait and into the Chukchi Sea, and there has been work on understanding what happens in the summertime.

For the largest part of the year there is no information as to current speeds and direction and what the water is doing under the ice. If there were an oil spill there in winter, the spill's trajectory could not be predicted.

Of particular interest is the focusing and the corresponding acceleration of water moving through the Strait itself; another is a split in the current when it clears the Strait, with one stream turning toward Arctic Russia, the other toward Alaska's Beaufort Sea coast. Very little is known about how these properties of Bering Sea water motion change with time and season or the masses and velocities involved.

The current meters are suspended about 20 ft (7 m) above the sea floor in water about 150 ft (50 m) deep.

The present current-meter stations were deployed from the NOAA ship DISCOVERER last summer to form an array of 19 submerged meters. Each mooring (fig. 52) consists of a cylindrical meter--about the size of a loaf of bread--attached to a swivelled vane that senses the direction of water motion. The meter is suspended on a cable held taut by a buoyant, streamlined float, and anchored at the bottom by a heavy concrete weight. The cable is connected to the anchor by a coupling that can be acoustically triggered, permitting a string of floats to raise the apparatus to the surface for retrieval.

Four current meters are set west of Cape Prince of Wales, the American side of the Bering Strait. Seven more are moored in the Chukchi Sea in a shallow arc westward from Cape Lisburne, almost the northwest corner of Alaska. Two meters are installed at the mouth of Kotzebue Sound and two more are in a line south of Nome in Norton Sound. Three are set along a southeastward line from St. Lawrence Island in the Bering Sea to the Yukon River delta, with a fourth meter northwest of St. Lawrence Island.

The meters will be recovered next summer and their data record removed for subsequent analysis by the Seattle oceanographers.

CURRENT-DEPTH MEASUREMENT DEVICE CONTRACT AWARDED

A contract has been awarded by NOAA for a 20-mo exploratory program to develop a shipboard Current-Depth Measuring Subsystem.

The subsystem will measure subsurface currents to a depth of 100 m below the vessel, and a ship's speed relative to the sea bottom to a depth of 150 m while the vessel is underway.

The subsurface current measurement is made by observing the Doppler shift frequency of a pulsed acoustic wave back-scattered from selected levels in the water mass. The first phase of the three-phase contract provides for a complete analysis of this technique prior to the construction and testing of the system. After field tests and technique development, the subsystem will be tested aboard a NOAA vessel investigating ocean dumping and energy-related pollutants.

FOREIGN AMVER VESSELS CONTRIBUTE TO OBSERVATION PROGRAM

A copy of the letter below to the U.S. Coast Guard Commander, AMVER, was sent to the Mariners Weather Log. Included with the letter was a list of 121 foreign vessels that contributed at least 25 observations in any one month and a total of 100 per year for 1976. Only those months where the threshold value of 25 observations was met were included. Using this criterion, 15 ships averaged over one observation per day. The East German BREMERHAVEN led the list with 561 observations, followed by the:

GYPSUM KING	Great Britain
BLUMENTHAL	East Germany
GYPSUM EXPRESS	Great Britain
ELSFLETH	East Germany
NORD POL	Denmark
WESERMUNDE	East Germany
DELTA GAS	East Germany
CANADA MARU	Japan
DAIAN MARU	Japan
NORSE VIKING	Great Britain
NIENBURG	East Germany
DAISHIN MARU	Japan
MINDEN	East Germany
VEGESACK	East Germany

National Weather Service
Forecast Office
30 Rockefeller Plaza
New York, NY 10020

January 25, 1977

Commander, Atlantic Area
United States Coast Guard
AMVER
Governors Island, New York 10004

Dear Sir:

The following AMVER vessels were extracted from a National Weather Service printout received from Data Acquisition.

These vessels are not in the National Weather Service's ship program. For the year 1976, they made a tremendous contribution to the data acquisition ship program by reporting weather observations while on the high seas. Thousands of weather observations were taken by these vessels and forwarded to the National Weather Service.

The only means of identification were their call signs. With the aid of the Coast Guard's publication, "List of Merchant Vessels With SAR Data," I was able to ascribe a ship name and country of registry to the call sign.

In order to cull the more noteworthy vessels from the printout, a threshold value of 25 observations per month and one hundred for the year was used to make this compilation possible.

Sincerely,

Robert W. Baskerville
Assistant Port Meteorological Officer

NEW INTERNATIONAL RULES OF THE ROAD

New International Rules of the Road for marine traffic will go into effect July 15, 1977, for all U.S. vessels on the high seas.

Appearing in the March 31 issue of the Federal Register, the 1972 International Collision Regulations will replace the 1960 International Rules currently in effect. The new regulations were ratified by the United States in November 1976.

The 1972 International Collision Regulations are quite similar to the 1960 rules, but in some specific cases significant changes have been made. Most notable of these are provisions for "early action" by the "stand-on" (previously the "privileged") vessel; new lights for vessels constrained by their draft; new sound signals for vessels overtaking in a narrow channel; a requirement for "safe speed" at all times to replace the old "moderate speed" rule; and new emphasis on the duties and responsibilities of the lookout.

The International Collision Regulations include technical specifications for lights, shapes, and whistle signalling devices to replace the vague requirements of the 1960 rules. A rulemaking document entitled "Alternative Compliance" and appearing in the same Federal Register specifies the manner by which vessels of special construction and purpose may, for the first time, be certified to deviate from these new international requirements.

As previously announced by the Commandant, the Coast Guard will not require vessels of less than 20 m (65 ft) to be retrofitted to meet the technical specifications of the new rules. Such vessels are acceptable if they are properly fitted and showing lights in general conformance with the requirements of the 1960 International Rules of the Road. Other technical specifications recognizing the limitations of smaller vessels but paralleling the requirements of the new Rules of the Road will be published at a later date and will apply to vessels built after August 1, 1978, the start of model year 1979.

The Coast Guard publication "Rules of the Road, International-Inland," CG-169, is being revised to reflect the new International Rules of the Road and should be available to the public through Coast Guard Marine Inspection Offices by May 1977. This will be in time for mariner's licensing examinations given after June 1, which will be based upon the new 1972 regulations.

SAILBOAT SINKS IN PACIFIC; THREE FOUND AFTER LONG ORDEAL ON RAFTS

When the Liberian vessel ORIENTAL FINANCIER located Durel Miller and Nancy Perry on a raft some 800 mi west of San Francisco, Calif., on October 18, 1976, it spurred a massive search for the three other missing crewmembers from the ill-fated sailing vessel SPIRIT. Miller told the master of the ORIENTAL FINANCIER that he and four others had left Hawaii bound for California on September 12 and ran into heavy weather on the 20th. On that day they heard what seemed like a loud crash or explosion and within moments the boat began to sink in the 18-ft seas. Miller and Perry reached one liferaft and three other persons on board scrambled into another. As night approached, however, they lost sight of the other raft.

When this information reached the Pacific Area Coast Guard Headquarters in San Francisco, a search plan was drawn up, and in the following 6 days more than 200,000 sq mi of Pacific Ocean were patrolled by Coast Guard, Navy, Air Force, and Air National Guard units. In addition, over 25 merchant vessels responded to the call for help with the majority of them volunteering valuable time to search for the missing raft.

Finally, on the afternoon of October 24, the missing liferaft and its lone occupant were located by a Coast Guard C-130 rescue plane flying out of San Francisco. Within 2 hr, the Coast Guard cutter CAMPBELL came on scene and lowered a boat to retrieve Bruce Collins who was in fairly good condition though he had gone without food for nearly a month. Collins was returned to San Francisco and related that his two companions on the raft had passed away and were buried immediately at sea. Miller and Perry, the other two survivors, remained on the ORIENTAL FINANCIER and were taken to Yokohama where they were also listed in good condition.

As it has so many times in the past, the response and cooperation of the merchant fleet during this massive rescue effort proved invaluable and demonstrated the honor and tradition of mariners everywhere that makes the AMVER system work.

NOAA ANNOUNCES NEW COASTAL WAVE MONITORING PROGRAM

A coastal wave monitoring program to collect wave data at offshore locations for scientific, environmental, and engineering projects has been initiated by NOAA.

The new research program, which involves at-sea wave measurement and statistical analysis of wave data, is based within NOAA's National Ocean Survey. It will provide wave condition information for offshore structure design, beach erosion prevention, improvement of marine forecasts, ocean construction projects, marine operations planning, and coastal zone planning.

The NOS Office of Marine Surveys and Maps will concentrate 1977 efforts on an evaluation of wind and wave measurements methods to be calibrated with the wave data, and the establishment of procedures to provide real-time wave data to marine forecasters.

With follow-on funds, wave monitoring is planned off the Atlantic coast beginning in 1978, in the Gulf of Alaska in 1979, and in other coastal regions in the following years.

NOAA SPACECRAFT MONITORS GULF OF MEXICO CURRENTS

Pictures from space helped mariners sailing the eastern Gulf of Mexico this past winter to conserve fuel and improve transit times by showing them where Gulf currents are flowing through that body of water.

In addition, commercial fishermen in the area are using the information to locate potentially more productive fishing grounds.

The information on the Gulf Loop Current (fig. 53), a circulation of water that moves roughly clockwise through the eastern Gulf of Mexico, comes from a geostationary satellite operated by NOAA. The satellite, GOES-1, is in an orbit which permits it to remain in about the same spot over the Equator at an altitude of about 22,200 mi (35,720 km).

An infrared sensor aboard the spacecraft senses the warmer waters of the current. This information is relayed to NOAA computers near Washington, D.C., and converted into pictures which are in turn transmitted to a NOAA Satellite Field Services Station in Miami, Fla. There, analysts determine and plot the location of the Loop Current's coastward edge by latitude and longitude. The material, now in the form mariners can use, is sent three times a week to NWS offices along the Gulf Coast.

The maximum Loop Currents, which can flow up to a speed of about 3-1/2 kn, are found about 9 mi (15 km) inside the coastward edge of the Loop.

The Loop analysis is being provided until May. At that time, as Gulf waters warm up to about the same temperature as the waters of the Loop Current, the temperature differential is difficult to see on the infrared imagery. The analysis will be resumed in November when the general water temperature declines once more.

Last winter, in a pilot program, a number of mariners used the Loop Current information in plotting navigation courses, sailing in the current when headed in the direction it was flowing and avoiding it when headed in the opposite direction. Improved transit times and fuel savings were experienced.

Since certain species of fish sought by commercial fishermen in the Gulf prefer water temperatures close to those found along the edge of the Loop Current, the location of the current at any given time is of value to the fisherman.

Figure 53.--A typical circulation pattern of the Gulf of Mexico Loop Current. Numerals 08 and 09 refer to the dates January 8 and 9 on which the features were seen on satellite imagery. The elongated circle northwest of Key West, Fla., identifies a warm eddy that had separated from the current.

NOMINATIONS FOR SHEPHEARD AWARD FOR MARITIME SAFETY

Nominations are being accepted for the second annual Rear Admiral Halert C. Shepheard Award for Achievement in Merchant Marine Safety.

The award is given either for a single outstanding contribution to merchant marine safety, or for dedication to, and constructive participation in, activities associated with maritime safety over a period of time. Nominees may include such individuals as ship operators, naval architects and marine engineers, ship repairers, ship builders, and those associated with ship operations, government, or marine associations.

The award was established by the American Institute of Merchant Shipping (AIMS) in 1976 in honor of the late Rear Admiral Shepheard, who served in the

U.S. Coast Guard as Chief, Office of Merchant Marine Safety, and was internationally acclaimed for his work in the field. The award is administered by the American Bureau of Shipping (ABS).

Nominations should be submitted to Rear Admiral Halert C. Shepheard Award, c/o Robert T. Young, Chairman and President, American Bureau of Shipping, 45 Broad Street, New York, NY 10004. The deadline for receipt of nominations is September 1, 1977. The award will be presented at the annual ABS Board of Managers dinner in November.

The award consists of a Steuben crystal eagle, a leather presentation book, and a citation. The 1976 recipient was John L. Horton, Manager, Marine Division of Cleveland Cliffs Iron Company, Cleveland, Ohio.

OCEANOGRAPHERS FIND HOT WATER, UNUSUAL ORGANISMS ON GALAPAGOS RIFT

Scientists from the Woods Hole Oceanographic Institution and other institutions diving in the submersible ALVIN report they have examined in detail several hot water vents on the deep ocean floor. Groups of animals apparently thriving in water up to 9°C (16°F) warmer than the normally near-freezing surrounding water have shown the observers where to focus their studies. At these depths, 2,500 to 2,700 m (about 9,000 ft), the seascape is usually devoid of such clusters of large organisms.

A record 11 dives in 11 days were made on the first half of a cruise beginning February 1977 to the Galapagos Rift in the Pacific Ocean as scientists seek to enlarge their understanding of the history of the Earth. This is the third major expedition over the past 4 yr to spreading centers where huge plates on which the continents ride are moving and growing very slowly.

As these tectonic plates move over the globe, new volcanic material wells up from the Earth's interior to fill gaps between them. Observations by scientists inside the 23-ft ALVIN and from photographs made by a camera sledge towed by the surface vessel KNORR of the Woods Hole Oceanographic Institution have matched those made on the Mid-Atlantic Ridge in 1974 and in the Cayman Trough near Cuba early in 1976. Bulbous pillow structures some 30 cm (about 1 ft) across and relatively flat flows of lava are typical. The Galapagos work has presented the first observations of active hot water vents emerging from holes about the size of a cereal bowl in pillow lava.

The ease of finding such vents at Galapagos may be because of the relatively flat topography of the area, according to the Chief Scientist aboard the KNORR for the first half of the Galapagos cruise. The highest elevation in the Galapagos is about 300 m, while on the Mid-Atlantic Ridge mountains up to 2 km high were found. The rougher terrain probably allows freer interchange of warm water circulating through the subsurface rock with the bottom seawater. The more even terrain of the Galapagos rift may also make it easier to find the warm water vents.

The scientists call the animal communities clustered around the vents "clambakes." Fields of dandelion-like organisms (possibly soft coral or crinoids) and clams up to 10 in across and up to 10 other species have been observed in these communities, which stretch from a few to tens of meters across. The abundance of the "clambakes" was unexpected, and there are no biologists on the expedition, so positive identification will wait until the geologists and chemists aboard return to their homeports with samples.

ALVIN carries equipment on these dives designed especially for studying the hot water vents, which were first spotted in photographs taken last summer during work by the Scripps Institution of Oceanography research vessel MELVILLE. Studies of heat flow through the bottom and of near-bottom water temperatures in the area have been underway for several years using towed instruments. The current hypothesis is that there are large convection currents that move water down through sediment and rock layers, perhaps several km, where it is heated, and then it rises by percolating back up through the rock and sediment layers to mix with ocean bottom water. The scientists have found higher temperatures in bottom features about 20 km south of the rift in curious mounds which occur in straight lines. The mounds are about 20 m wide and rise to as much as 20 m above the flat sedimented bottom with side slopes up to 80 degrees. These mounds are also believed to be related to hydrothermal circulation.

A temperature sensor with digital readout inside the sub was designed and constructed at the Woods Hole Oceanographic Institution for this cruise, and ALVIN is equipped with a water collection hose intake and sampling system designed at Oregon State University for precise placement at the vent with the sub's mechanical arm. Another device, which also measures temperature, salinity, pH, dissolved oxygen, and suspended matter in the water, was constructed at Scripps based on instrumentation used in the large Geochemical Ocean Sections study conducted by surface ships in 1972 and 1973.

As the seawater circulates through the subbottom rocks, it leaches metals and other elements from them. Analytical work by chemists aboard KNORR has shown the water at each vent to be distinctive with high concentrations of radon, dissolved hydrogen, silica, and hydrogen sulfide, and low concentrations of oxygen and low pH.

An ocean bottom monitoring system was placed at one of the vents at the end of the first half of the cruise, when KNORR, ALVIN, and ALVIN's mother ship LULU went to port in the Galapagos Islands for rest and refueling. This system was to record temperatures and water currents at the vent for 10 days before recall to the surface at the beginning of the second half of the cruise. The ships departed March 5, 1977, and the second half of the diving program commenced March 8. Time on the cruise may allow up to 12 additional dives.

One of the major questions raised by the large biological communities around the hot water vents on the Galapagos Rift is what do they eat. A marine microbiologist at the Woods Hole Oceanographic Institution suggests that the unusually high amount of life observed near the underwater springs is only marginally related to the increased temperature. The basis for this phenomenon is probably a well known microbiological one which occurs wherever there is high hydrogen sulfide in the water. Though well known in shallow water, this is the first known occurrence in the deep sea. The source of biological activity in the

deep sea is usually assumed to be organic matter that reaches the sea floor through sedimentation from surface waters. At the Galapagos vents the source of energy for the growth of organisms apparently emerges from the submarine springs in the form of hydrogen sulfide. This reduced inorganic sulfur compound can be used by a certain group of bacteria as electron donors, that is, the source of energy, for turning carbon dioxide into organic carbon. This is basically comparable to the process green plants employ with the aid of light instead of reduced sulfur. Profuse growth of these sulfide-oxidizing bacteria, then, produces the ideal food for filtering organisms, which may include the large clams or, more likely, smaller organisms on which they feed. With this food chain, the amount of life found around these springs will be more or less directly related to the amount of hydrogen sulfide contained in the emerging water. The rates at which these biological transformations occur will also determine how much biomass is produced, and temperature and pressure will affect the rate.

MARINE WEATHER REVIEW

The SMOOTH LOG (complete with cyclone tracks [figs. 57-60], climatological data from U.S. Ocean Station and Buoys [tables 17 and 18], and gale and wave tables 19 and 20), is a definitive report on average monthly weather systems, the primary storms which affected marine areas, and late-reported ship casualties for 2 mo. The ROUGH LOG is a preliminary account of the weather for 2 more recent months, prepared as soon as the necessary meteorological analyses and other data become available. For both the SMOOTH and ROUGH LOGS, storms are discussed during the month in which they first developed. Unless stated otherwise, all winds are sustained winds and not wind gusts.

Smooth Log, North Atlantic Weather

November and December 1976

SMOOTH LOG, NOVEMBER 1976--This was a rough month for ships, especially over the western part of the ocean. The area off the east coast of the United States was the favorite area of cyclogenesis and tracks. The main concentration was from near Cape Hatteras to east of Cape Race. Off Cape Race approximately half the cyclones curved north-northwestward toward Greenland and the Labrador Sea, while the other half continued northeastward following the climatological path toward Iceland.

The monthly mean pressures were more intense than the long-term mean. The Icelandic Low consisted of two centers as climatology indicates, but they were shifted many miles southwestward and deeper. The climatic positions are near 61°N, 30°W, (1003 mb), and 68°N, 00°W (1005 mb). This month they were near 56°N, 52°W, at 997 mb and 61°N, 30°W, at 998 mb. The Azores High was shifted in the opposite direction--northeastward. It was 1024 mb near 39°N, 19°W, versus the climatic 1019 mb near 35°N, 32°W.

There were two major anomaly centers. The largest, a negative 13 mb, was centered over Belle Isle. Its influence was felt from the northeastern United States to Scotland and Norway. The other center was plus 7 mb off Lisbon near 39°N, 14°W. This area was shaped like a large right foot with the center corresponding to the ball of the foot. The heel would be near 25°N, 55°W.

The 700-mb, upper-air gradient was much more intense with higher winds. This was partially due to an anomalous LOW near Hopedale on the Labrador coast of Canada. The trough was slightly west of and parallel to the east coast of the United States. There was slight ridging off the European coast with another trough over central Europe. There were a large negative anomaly centered off the Strait of Belle Isle and a positive anomaly that stretched southwestward from northwestern Spain.

There were no tropical cyclones this month.

Extratropical Cyclones--The first storms of the month formed in October; therefore, they are described in that Smooth Log. This storm formed near Norfolk, Va., at 1200 on the 5th. It was 986 mb over Nova Scotia 24 hr later. At 1800 the SEA-LAND CONSUMER, at 39.2°N, 57.5°W, encountered 41-ft swells. The drilling ship VGBZ fought 52-kn winds and 26-ft swells. The central pressure was plummeting. At 0000 on the 7th, it was 956 mb between Newfoundland and Anticosti Island. There were strong winds all around the storm, but especially in the northeastern quadrant. The JOHN CABOT (51°N, 50°W) and the POLARNYE ZORI (52°N, 55°W) both reported howling 60-kn winds from the east-southeast. The VGBZ (43.5°N, 60.4°W) suffered 50-kn winds, 10-ft seas, and 44-ft swells. The SEA-LAND CONSUMER was now at 39.7°N, 54.7°W, with 49-ft swells.

By 1200 the pressure had risen slightly, but this did not help the SEA-LAND COMMERCE (40°N, 49°W)

with 41-ft swells. A SHIP at 58.3°N, 58.6°W, reported 56-kn winds. The LOW was traveling along the Labrador coast. At 0000 on the 8th, 65-kn winds were observed by a SHIP at 56.8°N, 56.9°W, with 25-ft waves. On the 9th the LOW was south of Ungava Bay and only affecting those ships that braved the cold water of the Labrador Sea.

This storm formed in one of the favorite areas for cyclogenesis--off Cape Hatteras. The first analysis of the 1200 chart on the 8th showed a well developed frontal wave. The DAWSON was at 40.4°N, 55.4°W, with 50-kn southwesterly winds. The AMERICAN CHAMPION (33°N, 71°W) had 50-kn winds and 18-ft waves, while the SHERMAN (38°N, 72°W) measured 45 kn and 13-ft waves. At 0000 on the 9th, the ALERT experienced 60-kn winds near 42°N, 65°W. Far to the southwest, 15 mi southwest of Frying Pan Light, the 101-ft yacht LADY MARGARET reported taking on water soon after midnight. The Coast Guard cutter CHILULA diverted to assist as the yacht reported loss of her bilge pumps. A C-130 dropped pumps, but the LADY MARGARET was unable to retrieve them due to heavy seas. Later the skipper radioed that there was smoke in the cabin and the vessel was on fire, so they were abandoning ship. A helicopter from Elizabeth City rescued eight survivors on a liferaft, but a ninth person was missing. The EXXON CHESTER located the body that morning.

The storm was following the same track as the previous storm, only slightly eastward. At 1200 the LOW was 963 mb on the south coast of Newfoundland. A ship, south of St. Mary's Bay at 45.7°N, 55.6°W, was tossed by 65-kn winds and 26-ft seas. Another fought 60-kn easterly winds north of St. John's. By 1200 the winds had shifted to the southwest at 66 kn driving 25-ft seas. The ANTON DOHRN was battered by 33-ft seas near 46°N, 56°W.

At 0000 on the 10th, the 955-mb LOW was near 53°N, 55°W. The JOHN CABOT, near 51°N, 48°W, held her bow into 65-kn winds. By 1200 the winds were only 50 kn, but the swells had increased to 36 ft. There were several coastal and ship reports of 40 kn and waves of 20 to 25 ft. At 1800 the CABOT's swell report was 39 ft.

On the 11th, the storm turned westward and then southward as it weakened. At 0000 on the 12th, the pressure had risen to 978 mb. Later in the day the storm disappeared from the analysis.

As the previous storm moved northward, an area of low pressure moved out of New England, and a LOW developed near Sable Island late on the 10th. The LOW tracked northeastward as the other LOW turned to the west, then back to the south. A SHIP near 40°N, 55°W, reported 45-kn gales. The VGBZ measured 50-kn winds well southwest of the center at 0000 on the 12th. At 1800 the ERLANGEN was over 900 mi south of the storm with 60-kn winds as a trough line passed. At 0000 on the 13th, the 962-mb LOW was near 58°N, 39°W. The ANNA JOHANNE, just south of Kap Farvel, had 60-kn winds, a thunderstorm, and 26-ft waves. A ship just southeast of the center had 45-kn winds and 20-ft waves. The DART AMERICA was far south at 45°N, 38°W, with 50-kn westerlies and 23-ft waves. The SEA-LAND ECONOMY was even farther south near 29°N, 40°W. The report read calm winds and no seas, but the swell was 39 ft. This could possibly have been an erroneous report, or the high swell could have been propagated from the several severe storms to the northwest in a short period of time. At 1200 the strong winds had moved as far east as the Irish coast as attested to by the 56-kn report at 51.4°N, 18.9°W, by the CASUARINA. By the 14th a new LOW moved in from the south and took over the circulation.

In approximately 6 days this storm traveled from the balmy Gulf of Mexico to northern Greenland. It started in an inverted trough over the Gulf of Mexico late on the 13th. A large, cold HIGH was centered over Missouri. The trough moved eastward, and by 0000 on the 16th, gained strength as it moved past Cape Hatteras. At 0600 on the 17th, the SEA-LAND MARKET was pounded by 50-kn westerly winds and 33-ft seas near 34°N, 48°W. At 1200 the LOW was 966 mb near 48°N, 45°W. The ATLANTIC CHAMPAGNE (47.5°N, 43°W) was pounded by 60-kn winds and 25-ft seas with a pressure of 970.5 mb within a few miles of the center. Ships were reporting 40- to 45-kn gales on both sides of the front south to nearly 30°N. Six hours later the CITY OF DUNDEE found 31-ft swells near 50°N, 44°W.

As the storm approached the southern tip of Greenland on the 18th, it turned westward and moved up the west coast of Greenland. The front extended south-southeastward carrying the circulation as far south as 25°N in a sharp trough. It was the major circulation system between Europe and North America. At 1200 the BERNES, near 59°N, 23°W, was headed eastward with 60-kn southerly winds and being beaten by 44-ft seas and 39-ft swells. On the 19th, another LOW developed on the front on the east coast of Greenland as the original LOW dissipated near Thule.

A trough formed off the coast of New England on the 18th. By 0000 on the 19th, it had moved eastward to near longitude 60°W, and a deep, 976-mb LOW developed near 42°N, 60°W. The GREEN LAKE (33°N, 52°W) had 60-kn winds. At 0600 the DJATIPURA had 63-kn southeasterly winds and 33-ft swells on her port quarter near 36.6°N, 52.4°W. The VGBZ (43°N, 62.2°W) on the other side of the LOW was endangered by 68-kn northwesterly winds. The waves were only 16 ft. There were several 40- to 50-kn winds. At 1200 there were seven reports of winds 50 to 63 kn. Among these, the GREEN WAVE plowed into 41-ft swells at 33°N, 56°W. The GPZU (44.8°N, 52°W) reported howling, 94-kn winds at 1800. There were four reports of swells over 30 ft.

On the 20th, the 968-mb LOW was over the Gulf of St. Lawrence and moving northwestward. High winds and seas were continuing. By the 21st, the LOW had moved inland and the windspeeds had decreased to about 45 kn. VGBZ and CG11 both reported 33-ft swells south of Newfoundland.

On the 22d a frontal wave developed south of the LOW and moved around the eastern perimeter. On the 24th it became a major cyclone.

This was the frontal wave mentioned above. The winds were not too extreme, but there were high seas and

swells. The LOW raced northward and at 1200 on the 23d was near 56°N, 45°W, at 978 mb. There was a very tight pressure gradient on the east side of the occlusion that stretched southward from the LOW to 44°N. The AMERICAN LEGEND at 41.5°N, 62.3°W, measured 42-kn winds and 12-ft seas. The ALBRIGHT PIONEER near 50°N, 35°W, was rolled by 23-ft swells on her port side. On the 24th the STAGHOUND had 45-kn gales and 20-ft seas with 26-ft swells. The LOW moved onto Kap Farvel and split into two centers, one of which looped over the Labrador Sea before dissipating on the 26th, and the other traveled northeastward over Iceland.

Monster of the Month--A long, relatively straight northeast-southwest oriented front stretched from the western Gulf of Mexico to the mid-Atlantic on the 28th. Frontal waves had been forming and dissipating along the front. On the 1200 chart one was analyzed over the southern end of the Appalachian Mountains. This wave was able to maintain its identity and grow as it raced northeastward. On the 29th the front extended to the English Channel. Ocean Weather Station Romeo measured 36-ft seas. The upper-air flow was zonal from the central United States to the west coast of Europe. The long fetch of westerly winds resulted in high seas and swell all along the front, especially south of it.

At 1200 on the 30th, the LOW was 983 mb near 54°N, 45°W. The FROSTFJORD had fought 68-kn winds near 44°N, 30°W, at 0600. Romeo was being tossed by 36-ft seas again. The CIROLANA was sailing with 43-ft swells on her stern at 45.9°N, 17.5°W, and Romeo was fighting to stay on station with 33-ft seas. On December 1, a band of 40-kn winds could be analyzed from Newfoundland to Ireland. At 0600 Charlie measured 54-kn westerly winds and 26-ft seas. By 1200 the 970-mb LOW had raced to 55°N, 14°W. Three ships in the vicinity of 51°N, 22°W, reported winds over 50 kn. OWS Romeo had 30-ft seas and the PHILOSOPHER (46°N, 11.2°W) had 33-ft swells. At 1800 the FROSTFJORD's report at 47.8°N, 15.6°W, read an outstanding 100 kn. The ATLANTICA MARSEILLE off Lands End had 70 kn, and a nearby ship reported 36-ft swells. At 0000 on the 2d, Romeo was now being bruised by 39-ft seas. Charlie had 26-ft seas. The Liberian tanker ENERGY VITALITY ran aground in Jade Bay near Wilhelmshaven.

As the LOWs moved into the North Sea, they turned northward and were absorbed into a large, multicentered LOW that dominated the North Sea. The cyclonic circulation of this huge system stretched from Spitsbergen to North Africa and Greenland to Moskva. The high winds and seas still continued from the Labrador Sea to the Bay of Biscay. On the 2d, the high winds pushed across Spain and France into the Mediterranean Sea. At 1200 three ships reported 50-kn winds and waves up to 33 ft between Algeria and France. At 1800 the UDKF was pounded by 60-kn winds and 20-ft seas east of Gibraltar. On December 3, the 75,000-ton tanker BEN FRANKLIN broke its mooring in Marseilles harbor, crushed the oil research ship FRANCESCA, and went aground. The 12 crewmembers on the FRANCESCA were rescued.

There were still strong winds and heavy seas upstream as OWS Charlie still contended with 25-ft seas. The 3FEP had 60-kn winds and 33-ft seas only a few miles off the north coast of Spain. Five other ships in the Bay of Biscay reported waves over 30 ft. The MONTE ROTONDO in the Ligurian Sea fought 55-kn winds.

On the 4th, the LOW consolidated into one 970-mb center over the Skagerrak and a frontal wave over the Adriatic Sea. The gradient around the main LOW had relaxed, but it was still tight between 40° and 50°N west of France and Spain where the winds were 35 to 45 kn and the waves about 25 ft. On the 5th, the LOW moved into the Barents Sea.

During the period November 25 to December 3, there were six casualties in which weather was a factor in the Mediterranean Sea.

A long-lived LOW formed over Tunisia on the 18th out of an inverted trough over Algeria, Tunisia, and Libya. The LOW remained over Tunisia until the 19th when it moved eastward over the sea. The severe weather associated with this LOW was mostly thunderstorms and showers. There were isolated land-station reports of 30-kn winds. It dissipated over the Ionian Sea on the 21st, and another center formed in the same low-pressure system over Sardinia. At 1200 on the 23d, the 997-mb LOW was centered over the southern tip of Greece. The SOUTHERN SUN ran aground during heavy weather with 40-kn winds at Zuetina. There were no observations plotted along that coast, but the CLAN ALPINE noted 42-kn northerly winds, 16-ft seas, and 26-ft swells near 37.7°N, 7.5°E, and the ZONNEKERK had 36-kn winds and 12-ft seas near 37.7°N, 8.4°E, at 0600. By the 25th this LOW had deteriorated into a trough over Turkey, but a strong flow continued over the Agean Sea with the trough line over Rhodes. The 4,497-ton RECHITSA sank off Rhodes after its cargo shifted in rough weather. Two crewmembers were rescued by the Cypriot ELENOS.

On the 26th, another LOW at 1000 mb generated or regenerated in the trough near Rhodes. This storm claimed two ships that day. The 1,958-ton ROMIOSSINI drifted aground at Laurium and caught fire. The 1,061-ton PARNES and MARDER collided in Jounieh Bay while at anchorage during heavy weather. Several ships reported winds in the gale category south of the Ionian Sea. Among them, the MUKACHEVO measured 21-ft seas and the VENDEE 52-kn winds. By midday on the 27th, the 1003-mb LOW was north of Cyprus, and the 1,006-ton MONA sank after striking a rock near Chebba during heavy weather. The crew and two passengers were rescued. The LOW moved over Syria and Iraq on the 28th.

Casualties--Fire broke out in the engineroom of the 11,500-ton SEATTLE on the 7th about 1,400 mi east of New York. Twenty crewmen abandoned ship and stood by in lifeboats riding 12-ft swells on 6-ft seas, while the remaining crew fought and controlled the fire. The USCGC TANEY rescued three persons from a sinking shrimp boat about 250 mi northeast of Norfolk, Va. The shrimp boat was taking on water in 18- to 20-ft seas. The 8,461-ton RUPSA and the 13,359-ton AGELOS RAPHAEL collided on the fogbound St. Lawrence River. The 11,547-ton Turkish bulkcarrier ZEKI sank near 48.3°N, 28.3°W, after springing a leak in heavy weather.

On the 13th, the 11,144-ton OCEAN SOVEREIGN was pushed out of line with the Soo Locks by 30-kn wind gusts and jammed the approach channel. Traffic was interrupted for 8 hr until tugs straightened the vessel. The 699-ton MERCANDIAN SUPPLIER arrived Brest on the 14th with cargo shifted and deckload partly washed overboard.

The 3,372-ton Liberian-registered MELIAS was abandoned on December 1 after taking on water in heavy weather on the 30th. The crew was rescued. The 1,188-ton NASSAR grounded at Port Rashid breakwater on the 29th owing to high winds.

SMOOTH LOG, DECEMBER 1976--Normal cyclonic activity was concentrated from Nova Scotia to the Davis Strait and from Newfoundland through the Denmark Strait. Some storms also moved along the U.S. East Coast, in the North Sea, and the Mediterranean. An even more-than-normal flurry of activity occurred around the Gulf of St. Lawrence, resulting in a negative 6-mb sea surface pressure anomaly. This also caused a shift in the 1000-mb center of the climatic Icelandic Low from around Iceland to the seas between Greenland and Newfoundland. Less-than-normal activity left the Iceland region with a positive 11-mb anomaly at the surface and a positive 93-m anomaly at the 700-mb level.

A southwestward shift in the normal position of the 1021-mb Azores High from around the Azores to near 30°N, 40°W, caused a positive 4-mb surface pressure anomaly in these waters and a positive 28-m anomaly at 700 mb. Around the Azores, this shift and some weak storm activity resulted in a deficit of 8 mb at the surface and 80 m at 700 mb.

The month opened with a huge quasi-stationary 1030 plus mb HIGH, centered southwest of the Azores, dominating most of the weather south of 40°N. Over Europe lay the large, multicentered remains of a low-pressure system that had its origins back in November. The gradient between these two systems was responsible for the northwesterly gales and rough seas from the Bay of Biscay to Ireland. (See November Smooth Log.)

Extratropical Cyclones--The first major storm of December was spawned by the Great Lakes on the 1st and nurtured by the St. Lawrence River. By the 4th its 970-mb center was off the Labrador coast, and it was generating gales and rough seas out 500 mi to the south and southeast. The TORDALSFJORD ran into 30-ft seas in 50-kn winds some 300 mi southeast of the center. The LOW moved eastward across the North Atlantic at about 55°N. On the 5th the ATLANTIC CAUSEWAY battled 28-ft swells in 65-kn winds some 400 mi southwest of the 960-mb center, which was crossing the 30th meridian. The LOW reached a peak early on the 7th, when pressure fell to 956 mb. During this period, ships such as the DCHO, KAUNAS, and QUEENSGARTH were reporting 50- to 60-kn winds from near the center out 500 mi to the west and south. The AMERICAN ARGOSY, about 1,000 mi southwest of the center (43.5°N, 27.5°W), was battered on her starboard side by northwesterly 50-kn winds and huge 41-ft swells. It was about this time that the LOW turned northward brushing the Hebrides and finally moving into the Norwegian Sea where it filled a few days later.

Between the 9th and 15th, a series of rapidly moving, gale-producing LOWs moved northward across the shipping lanes of the northwestern North Atlantic. The first of these originated as a frontal wave in South Carolina on the 7th. The MOBIL AERO off Cape Cod was hit by 33-ft swells early on the 8th. On the 9th several ships reported winds of up to 55 kn in the vicinity of 40°N, 60°W.

The PRESIDENT EISENHOWER encountered the storm on the 8th and 9th as shown by their barogram trace (fig. 54). The pressure change after 0600 on the 9th is impressive even though the ship was moving toward higher pressure at 20 kn. The 3-hr pressure change on the 1200 observation was 12 mb. In a letter to the Marine Observations Branch, National Weather Service, along with a copy of the barogram and Ship's Weather Observation form, the Captain reported that the ship had encountered a series of squall lines with wind, snow, and thunderstorms on the afternoon and evening of the 8th. These probably account for the jump in pressure on the 8th at 2130.

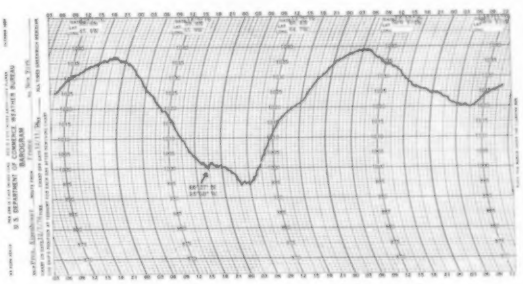


Figure 54.--The barograph trace of the PRESIDENT EISENHOWER from December 7 to 11.

Early on the 10th the SEA-LAND MARKET encountered 55-kn winds with 39-ft swells in the same area. Later in the day the EXPORT PATRIOT also had 55-kn winds and 33-ft waves near Cape Race. In 24 hr pressure fell from 986 mb to 938 mb. Winds of 45 kn were reported as far as 900 mi to the south. The ALSTER EXPRESS, EVELYN BOLTEN, EAGLE CHARGER, DXYL, and the BUOY were encountering winds of 45 to 60 kn with seas up to 35 ft. As this LOW began to fill on the east coast of Greenland, it was followed by another system that moved off the coast of Newfoundland on the 12th.

This storm originated in the Canadian Rockies, west of Calgary, on the 8th. It swung southeastward through the upper Midwest, then east-northeastward across the Great Lakes, where it began to organize on the 10th. Early on the 12th, sporting a 986-mb center just east of Newfoundland, the storm was generating 40- to 50-kn winds to the south, particularly behind its cold front, which extended back over the Carolinas. Moving northeastward, the storm continued to intensify to a peak of about 964 mb on the 12th. The IVAN AIVAZOVSKII encountered 50-kn winds, while the EVELYN BOLTEN ran through the front encountering 55-kn winds in 25-ft swells. Like the previous storm, this one petered out on the southeast coast of Greenland.

The next member of this storm trio developed south of Nova Scotia early on the 13th. Developing rapidly, the system raced northeastward across Newfoundland and then turned northward toward the Davis Strait. By the 14th the central pressure bottomed out at 948 mb, and 40- to 50-kn winds were being encountered out 500 mi to the south. Seas were running up to 30 ft as attested to by the EXPORT FREEDOM. Frederikshab reported 60-kn easterly winds as the storm center roared within 60 mi. At the same time the MANCHESTER CONCORDE battled 50-kn westerlies in 20-ft seas some 480 mi to the south. As the system entered the Davis Strait, it began to fill.

After a brief respite, another Newfoundland storm came to life as a frontal wave off the coast of Georgia on the 15th. This was the same day that the ARGO MERCHANT, carrying 182,600 barrels of No. 6 fuel oil, ran aground on Nantucket Shoals (fig. 55). The storm intensified and developed a second center as it moved northward. Late on the 18th the ESSO ANTWERP, about 200 mi east of Cape Hatteras, measured 50-kn winds and 13-ft seas. By the 17th the winds and seas in near-freezing temperatures prevented the Coast Guard oil cleanup team from going into action. The storm's new 972-mb center moved into the Gulf of St. Lawrence early on the 18th. Gales extended 600 mi to the south and east. In the Nantucket area, winds of 35 to 40 kn were common.

Figure 55.--The ARGO MERCHANT on the 21st after breaking up in heavy seas. U.S. Coast Guard Photo.

Within 4 days after the grounding more than 1.5 million gallons (about 20 percent of the cargo) had spilled and were being pushed southeastward. Meanwhile, the storm--which had deepened to 960 mb late on the 18th--moved northward and stalled between Labrador and Greenland on the 20th. It filled rapidly, but another system was beginning to affect the waters around Nantucket.

This new storm was spawned over Nebraska on the 19th. It intensified as it moved east-northeastward across the Great Lakes the following day. The LOW was spreading rain out 600 mi from its 994-mb center. Just as it reached the coast of Maine, the deepening 977-mb LOW turned northward on the 21st. Afternoon temperatures hovered in the teens and in single numbers in the North Atlantic States, and gale warnings extended from Maine to Virginia. New York and Boston reported 42-kn gusts. Battered by high seas, the ARGO MERCHANT broke in two early on the 21st. About 80 percent of its cargo was spilled in 50 plus kn winds and up to 30-ft seas. Early the next day, the forward section of the grounded tanker cracked, rupturing the forward cargo holds and releasing nearly all 36,000 barrels of oil remaining in the vessel. Northwesterly winds pushed the oil slicks toward the east-southeast. Meanwhile, the storm had deepened to 966 mb as it moved northward across eastern Quebec. The GUZJ ran into 60-kn winds off the coast of Maine. The ERAWAN, about 300 mi to the east, reported 45-kn winds in 30-ft swells. On the 23d the system weakened and turned northwestward up the Hudson Strait. It finally ended up over Hudson Bay on the 25th.

A frontal wave developed over Texas on Christmas Eve. On the 26th the LOW moved northeastward along the Gulf Stream and became a major storm. The pressure was 976 mb south of Cape Sable at 0000 on the 27th. On the 26th the winds were in the 40-kn gale and the seas were in the 16-ft category. On the 27th the winds increased to 60 kn and the seas to 33 ft. The BALTIMORE TRADER east of Charleston was pounded by 33-ft swells. The OVERSEAS ARCTIC and PIONEER COMMANDER had 60 plus kn winds on opposite sides of the front. Late on the 27th another LOW formed on the front near 40°N, 57°W, and the original LOW tracked northwestward to Hudson Bay. At 0000 on the 28th, the OVERSEAS ARCTIC reported 70-kn winds and 33-ft swells at 32.8°N, 57.4°W. Other ships were contending with 50-kn winds and 25-ft seas. A series of frontal waves were moving along the front, and ships found winds up to 60 kn and seas 20 to 30 ft as they encountered the storm.

A LOW developed along a front over northern Montana early on the 27th. It intensified very little as it moved east-southeastward through the Ohio Valley and across southern Pennsylvania on the 28th. However, once out into the Atlantic the storm turned northeastward and began to deepen. By early on the 30th, the now northward-moving, 979-mb LOW was centered just 100 mi south of Nova Scotia. Near its center winds were blowing about 40 kn and seas were running 15 to 20 ft. On the 29th at 1800, the FORE-

LAND (37.8°N, 70.5°W) reported northwesterly winds at 55 kn, while 500 mi farther east the MUENCHEN encountered 28-ft swells. It was on the 30th that the Panamanian tanker GRAND ZENITH, carrying 8 million gallons of heavy fuel oil, was last heard from about 30 mi from Cape Sable, Nova Scotia. In her last communication she reported very strong westerly winds and heavy seas. At 1200 the 964-mb center was in the Gulf of St. Lawrence. A few hours later some 350 mi southeast of Cape Sable, the DLHO reported 60-kn winds in 30-ft seas. The storm was at its peak on the 30th. It then stalled and began to fill over southern Labrador.

Out of a complex, multicentered low-pressure system that covered northern Europe and Scandinavia, a LOW developed about 250 mi northwest of Ireland on the 29th. Winds of 55 to 60 kn were already being reported by the OSTROV RUSSKIY and the URYX. Early on the 30th, the C7L, about 240 mi northwest of the center, battled 23-ft seas in 50-kn winds. The storm meandered southeastward, then turned northward on the 31st, crossing the Hebrides. Winds of 50 to 60 kn were common in the North Sea. The ZAFRA encountered 60-kn southerlies in 35-ft seas. The CHRZANOW ran into several consecutive days of 52- to 58-kn southerlies as she sailed westward along the coast of the Netherlands. In addition, she ran into another storm with 66-kn winds in the English Channel on January 1. By this time the original LOW was filling over the Norwegian Sea.

Casualties--There were two groundings on the 2d in heavy weather: the 500-ton BUCHENHAIN in the San Sebastian area with the crew rescued and the 2,496-ton VIRGO off Bordeaux whose crew was taken off by helicopter. On the 5th the Norwegian GERMA LADY (1,593 tons) sank off Feisten Light after developing a list probably due to cargo shifting in heavy weather. This crew was also rescued. The RAUTE touched bottom at Gooseneck Shoal in heavy snow and anchored at Morrisburg Channel, St. Lawrence River, on the 3d. On the 7th the HARRY L. ALLEN and the JAN T. HUTCHINSON became stuck in the ice while downbound in Lake St. Clair.

The worst traffic jam in 50 yr tied up more than 60 vessels on the St. Marys River on the 11th as the 716-ft ore carrier CLIFFS VICTORY ran aground in a shallow section of Neebish Channel while trying to avoid ice jams.

On the 26th the 42-ft sloop MYSTERE was abandoned in heavy weather off Cape Fear. The ship had encountered rough weather early that morning. By noon winds were gusting to 70 kn, and 20-ft seas were making conditions impossible. The Coast Guard was standing by; finally, after five passes the Swedish tanker FORT ALEZA was able to take the four-man crew aboard. Weather was too rough, however, to take the MYSTERE in tow.

Smooth Log, North Pacific Weather

November and December 1976

SMOOTH LOG, NOVEMBER 1976--The number of individual storms this month was fewer than normal, but the storms were generally large in size. The tracks did not follow climatology very well. There were two primary tracks; both originated in the Sea of Japan. One branch traced northeastward to the western Bering Sea. The other traced an easterly path until crossing the Date Line, then turned northeastward and then northward into the Gulf of Alaska. A secondary track from the vicinity of 40°N, 145°W, tracked into British Columbia.

The pressure pattern was deeper and more compact and rounded. There was only one 994-mb center for the Aleutian Low versus the normal three along approximately 53°N. This month's center was near 54°N, 160°W, not far from the climatic normal location of the center Low at 1002 mb. The Pacific High was split into two centers, both slightly higher in pressure than the climatic normal. The eastern 1021-mb center was near 33°N, 130°W. The western 1022-mb center, near 30°N, 170°E, was the most anomalous of the two. The split in the High was the consequence of the Aleutian Low being more rounded, rather than an east-west oval, resulting in a sharper trough that extended about 10° latitude farther south. A 1025-mb High was centered over western Montana.

There were two major anomaly centers that were a direct result of or directly affected the storms this month. A negative 10-mb center was near 51°N, 164°W, and a positive 8-mb center was near 55°N, 128°W. Both centers were large. There also was a positive 4-mb center near 30°N, 170°E.

The upper air showed two major troughs, both sharper than normal. One paralleled the Asian coast, and the other was from an anomalous low center near Dutch Harbor south-southeastward toward 30°N, 150°W. The normal ridge over the Rocky Mountains was higher and sharper than normal.

There was one tropical cyclone, typhoon Marge, over the western ocean.

Extratropical Cyclones--A high-pressure center moved over Japan on the 2d, and a LOW formed over the Sea of Japan on a weak front on the 3d. By 1200 on the 4th, it was 984 mb near 49°N, 151°E, with a good circulation moving northeastward. At 1800 the PRIMORSK discovered 52-kn westerly winds over the Sea of Okhotsk. At 0000 on the 5th, the RADE KONCAR was sailing near 47°N, 171°E, with 60-kn southwesterly winds on her stern. The NISSHIN MARU No. 2 plowed into 50-kn winds and 33-ft swells south of the LOW at 1200. At 1800 they were 70 kn and 46 ft.

At 0000 on the 6th, the LOW was 964 mb near 60.5°N, 178°E. The ORIENTAL was 600 mi to the south with 50-kn westerly winds and 33-ft seas and swells. The NISSHIN MARU No. 3 fought 50-kn winds

from the west-southwest and 46-ft swells at 50.6°N, 167.5°E. The PACGLORY had 54 kn from the same direction and 41-ft swells near 50°N, 170°E. Even farther south, near 47°N, 162°E, the OCTA measured 45-kn winds with 25-ft seas.

On the 7th this LOW dominated the circulation north of 45°N. The only other LOW of significance over the North Pacific was tropical storm Louise south of Honshu. There were three widespread reports of 60-kn winds--the JAMSONS (47.8°N, 152.5°W), the RADE KONCAR (49.6°N, 174.6°W), and another ship at 38.7°N, 176.7°E. There were also reports of 20- to 30-ft waves.

Late on the 7th, the LOW turned northwestward and then stalled near 62°N, 179°W, on the 8th and 9th. At 1200 on the 8th, the PHILADELPHIA, at 57.7°N, 148.6°W, was crashing into 46-ft swells. Even though the LOW was filling, far back to the west near 48°N, 166°E, a ship had 55-kn westerly winds and 20-ft seas. By the 10th another LOW had become dominant.

This vicious storm, which must be named the Pacific Monster of the Month, was the result of the combining of two LOWs, the extratropical remnants of typhoon Louise and a LOW that formed over Hokkaido on the 8th. They combined at 0000 on the 10th. At 0000 on the 9th, the ORIENTAL was southwest of the northern LOW with 60-kn northwesterlies. The PRESIDENT KENNEDY was ravaged by 90-kn winds, 20-ft seas, and 25-ft swells at 0300 about 90 mi south of the extratropical LOW. At 0600 both the NISSHIN MARU No. 2 (46°N, 158°E) and the PRESIDENT KENNEDY (37°N, 159°E) fought 70-kn northwesterly winds and waves of 23 and 33 ft, respectively. At 1200 (which would have been near midnight local time) the VAN FORT at 44.3°N, 166.7°E, was in the dark with measured 90-kn winds. No waves were reported as who in their right mind would venture out to determine what they were. Six hours later the UNION GREEN, southeast of the center, measured 70 kn with sea-level pressure at 951 mb.

The 0000 analysis of the 10th indicated a large LOW at 47.5°N, 177°E, with an exceedingly low pressure of 940 mb. A ship identified as SLKF was at 46.4°N, 178.2°E, with a pressure of 947 mb and 50-kn winds. The following are some of the higher wind and wave reports: JAMSONS (43°N, 170°W) - 80 kn, 33 ft; KATHRYN MARU (45°N, 166°E) - 86 kn, 39 ft; RYOKO MARU (45°N, 170°E) - 60 kn, 46 ft; SHUNYO MARU (41°N, 173°E) - 50 kn, 43 ft. At 1200 the LOW was analyzed as 938 mb. The SHUNYO MARU was now fighting 46-ft swells about 350 mi south-southwest of the storm's center. At 0000 on the 11th, the following ships were battered by high swell waves: CRYSTAL REED (35°N, 179°W), 41 ft; HARFLEUR (34°N, 175°W), 39 ft; TUBARAO MARU (40°N, 173°W), 46 ft. The wind reports had slacked to 50 kn or less. At 0600 the HAWAIIAN PROGRESS (34°N, 179°E) found 36-ft seas and swells. At 1800 the LOW was 963 mb near 49°N, 163°W. At 1815 the CARNELIAN-1 reported trouble in a radio message after a deckload of lumber broke loose and crashed over the side. At about 2100 the vessel's radio operator left his post to stand by his lifeboat station. The CARNELIAN-1 sank about 2,200 km northwest of Honolulu. The ship was approximately 800 mi southwest of the storm's center. Among those ships that responded to the distress call were the HUNTER and WISTERIA which picked up 14 survivors with one known dead. Eighteen other crewmen were missing. A U.S. Coast Guard plane spotted crewmen clinging to logs, atop an overturned lifeboat, and in rubber rafts dropped by the plane. The SHUNYO MARU, which had experienced 46-ft waves earlier, arrived on the scene after dawn on the 12th, and the cutter MELLON arrived from Alaska on the afternoon of the 13th.

At 1800 these ships reported high waves: AGANO MARU (35°N, 166°W), 33 ft; HARFLEET (45°N, 159°W), 41 ft; THOMAS E. CUFFE (37°N, 164°W), 33 ft; GOTZ (32°N, 177°W), 30 ft. At 0000 on the 12th, the SHUNYO MARU was at 37.8°N, 175.3°W, with only 30-kn winds, but the swells were 30 ft. The greatest number of high-wave reports were coming from the southeast quadrant of the storm between longitudes 150° and 160°W.

By 1200 on the 12th, the storm had filled to 970 mb and was weakening. This was aided by a frontal wave which was traveling eastward about 900 mi south of the center. A ship reported 33-ft swells near 40°N, 178°W, south of the frontal wave. A monstrous 30-ft surf hit Oahu and the north and northwest shores of the Islands on the 12th (fig. 56). On the 13th the storm's center crossed into the Bering Sea, but an extremely long fetch still existed from Kamchatka to 30°N latitude. On the 14th the frontal wave, now a large storm itself, moved into the Gulf of Alaska and became the dominant factor. At 1800 on the 14th, OWS Papa measured 55-kn winds and 30-ft seas with that LOW. The LOMPAC was at 50.6°N, 132.1°W, at 0600 on the 15th with mild 35-kn winds, but the seas were 22 ft and the swells 39 ft. Several other ships reported winds over 50 kn.

This was another very large storm, but it did not get nearly as deep as the previous storms, and it tracked farther north after deepening. It formed over the Sea of Japan on the 13th and moved northeastward over the Sea of Okhotsk. On the 14th two ships reported 50-kn winds southeast and northeast of the center. At 0000 on the 15th, a ship near Ostrov Iturup fought 66-kn winds.

By 0000 on the 16th, the LOW was 964 mb over the east coast of Kamchatka. The JAPAN CARRYALL (50°N, 164°E) and the SHOFUKU MARU (49°N, 165°E) both reported 60-kn winds and waves to 33 ft. At 0600 the SHOFUKU was smashed by 36-ft waves. On the 17th the WORLD PRIDE, near 51°N, 174°E, was sailing into 50-kn westerly winds and 33-ft waves. Waves of

Figure 56.--This photograph of the high surf was taken from Pupukea Beach Park on the north side of Oahu. Photo courtesy of Bernard K. Differ, Honolulu Forecast Office.

20 to 25 ft were reported by several ships southwest of the center. The storm dominated the northern ocean from Kamchatka to British Columbia and as far south as 35°N in the central ocean.

On the 18th the storm was in the decaying stage as a secondary LOW formed near Kodiak Island. Back near 171°E, the WORLD PRIDE was still being pounded by 30-ft waves.

This LOW formed on a trough line of the previous storm on the 19th. It scooted rapidly northeastward. The RADE KONCAR was tossed by 75-kn westerly winds near 42°N, 149°W, with 21-ft waves early on the 20th. At 1200 the 972-mb LOW was near 52°N, 146°W. The NEWARK (53.7°N, 136.3°W) had 60-kn southeasterly winds and 25-ft seas and swells at 1800. The PORTLAND suffered 60-kn winds, 15-ft seas, and 25-ft swells as she headed toward Cook Inlet. The CHEVRON MISSISSIPPI was negotiating the entrance to Cook Inlet with 50-kn easterly winds and 16-ft waves at 1200 on the 21st. Another LOW was moving into the Gulf of Alaska and, on the 22d, took over the circulation.

This LOW started on the 21st southeast of Hokkaido over the Japan Trench. It moved rapidly eastward with little change under zonal flow. Late on the 22d, it turned southeastward and started to expand its area of influence. At 1800 on the 23d, the PRESIDENT MADISON, near 35°N, 171.5°W, encountered 55-kn northwesterly winds and 30-ft seas. By 0000 on the 24th, the LOW was 980 mb near 37°N, 167°W. At that time the MADISON was headed into 60-kn winds and 34-ft seas.

Other ships were suffering as well. The ARNOLD MAERSK had 55-kn winds and 30-ft seas on her port side at 1200 on the 24th. At 1800 and at 0000 the next day, she was battered by 60-kn northerly winds; the seas were coded as 49 and 46 ft, respectively. About 180 mi south of the center, another ship had 50-kn winds and 30-ft waves from the west-northwest. The pressure was 974 mb at 0000. The ASIA MOMO measured 45-kn winds with 39-ft seas near 38°N, 168°W.

Late on the 25th, a new LOW center formed north of this one and rapidly became the major storm. Another LOW was approaching from the west with 45- to 55-kn winds south of its center. By 1200 on the 26th, the original LOW no longer existed, and the 0000 chart of the 27th indicated only one large LOW at 968 mb near 53°N, 167°W.

The RUSH (56.5°N, 170.4°W) measured 60-kn northeasterly winds at 1800 on the 26th and 33-ft seas on the 27th at 0000. The ALEUTIAN DEVELOPER north of Unalaska Island had bone-chilling, 66-kn winds. The KIKUKO MARU, 200 mi to the west, fought 33-ft swells from the northeast. A ship near the Pribilof Islands had below-freezing 50-kn winds and 33-ft seas. Fishing vessels off the Siberian coast were fighting 40- to 50-kn winds.

The LOW was moving westward, which is usually deadly as they quickly weaken and fill. The exstorm was last identified south of its original position at about the same longitude.

Tropical Cyclones, Western Pacific--Marge came to life in the western Carolines on the 6th. Moving northwestward, she took 2 days to reach tropical storm strength, near 18°N, 128°E. The following day Marge blew at typhoon strength for a few hours before returning to tropical storm intensity. She turned northward and moved through the Ryukyu Islands, west of Okinawa on the 9th. She continued to weaken before turning extratropical in the East China Sea late on the 10th.

Casualties--The Norwegian HOEGH ORRIS (6,705 tons) struck a pier at Seattle in heavy fog on the 10th. A 75-ft section of the pier was demolished. One of six crewmen was rescued after the 486-ton FUJI MARU No. 3 sank in stormy weather off eastern Kyushu on the 14th. The Panamanian SELANGAN (4,658 tons) was abandoned off Kunsan on the 14th after becoming waterlogged with a cargo of logs and sank on the 18th. The 4,438-ton Japanese RISING SUN sank in heavy weather on the 15th about 10 mi west of Hatoma Shima.

The 948-ton Korean BOO HEUNG No. 1 sank on the 17th near 36.8°N, 126°E, after running aground in poor visibility and rough seas. Sixteen crewmembers were missing. This was a very bad month for cargoes of logs. The 2,969-ton Panamanian MAY LILY, with a cargo of logs that shifted in heavy weather on the 23d, was abandoned and sank near 22°N, 126°E, on the 29th.

SMOOTH LOG, DECEMBER 1976--Waters around Japan are spawning grounds for many of the storms that roam the North Pacific in winter. This month, this was intensified. Many of these LOWs moved east-northeastward, remaining just south of the Aleutian Islands, and recurved into the Gulf of Alaska or Bristol Bay. This activity was reflected in the nearly normal position of the Aleutian Low. The increase in activity is reflected in the negative 13-mb anomaly at the surface and the negative 136-m departure from normal at 700 mb, both located near 45°N, 180°. This position is just southeast of the normal location of the center of the Aleutian Low.

The increased activity in these waters was at the expense of the normally cyclonically active waters off the Washington-British Columbia coast. A ridge in the upper levels resulted in a positive 83-m departure centered over Vancouver Island. At the surface, this was a positive 5-mb anomaly.

Two weak tropical storms, Nora and Opal, developed in the western North Pacific. One or two tropical cyclones are not uncommon in these waters.

Extratropical Cyclones--Two weak LOWs developed on the 4th. One formed in the northern Sea of Japan and moved eastward. The other was first detected just northwest of the Mariana Islands and moved northeastward. The two merged early on the 7th near 47°N, 177°E, and the resultant system developed into an intense storm. The HONG KONG PHOENIX, some 200 mi to the southwest of the center, ran into 50-kn winds amidst 20-ft seas. A few hours later, the TAKASAKA was battered by 56-kn winds in 30-ft seas near the storm's rapidly deepening center. The PACBARON had 61-kn winds with 23-ft seas at 39.5°N, 174.5°W. Central pressure plummeted to 934 mb by 1200. The OJI MARU, within 100 mi of the center, reported 65-kn winds in 30-ft seas with a 946-mb pressure and continuous heavy rain. She continued to battle these same conditions as the storm moved northward to near 50°N, 177°E. The system then began to stall. It remained stationary over the Rat Islands until the 10th. On the 9th, the SAJANSKIE GORY, bobbing in 22-ft seas, reported 52-kn winds about 250 mi north of the weakening 976-mb center. The following day the system moved eastward and continued to fill.

A LOW developed rapidly on the 10th, about 300 mi south of Atka Island in the Aleutians. Central pressure fell to 962 mb as the system headed northeastward the following day. The GUERAKL ran into 44-kn winds about 250 mi northeast of the center, while the 5LKJ encountered 45-kn winds the same distance to the east. The BREWSTER, also on the 11th, reported 40-kn winds 120 mi southwest of the center. As the storm moved northward the next day, she encountered about 6 hr of 60-kn winds. On the 12th, as the storm looped counterclockwise across southeastern Alaska and into Bristol Bay, the BREWSTER was raked by 50-kn winds, about 300 mi south of the center, as she got caught between the weakening LOW and a developing storm to the south. Seas and swells of 20 ft were common.

This short-lived storm began on the 11th near 45°N, 175°E. It took several days to develop as it moved on a track similar to the previous system. It moved northeastward recurving over the Alaska Peninsula and then into Bristol Bay by the 14th. On the 13th, when the 960-mb center reached the Alaska Peninsula, gales extended out 700 mi to the south. The GLADIOLUS, 250 mi east-southeast of the center, and the ALISHER NAVOI, 150 mi to the south-southwest, both encountered 50-kn winds. The latter ship reported swells estimated at 47 ft. The storm began to merge with the previous one, and by the 14th just one weakening 966-mb center remained. The system hung on until the 16th.

The Yellow Sea spawned a LOW on the 15th. It moved rapidly east-northeastward as it developed. On the 17th the LIONS GATE BRIDGE encountered 60-kn winds and 25-ft swells about 180 mi southwest of the 984-mb center, which was located near 43°N, 155°E. The following day gales were reported out to 600 mi from the 972-mb center. On the 19th, the system crossed the International Dateline. Forty- to 50-kn winds were common out 450 mi in the western semicircle. The PRESIDENT KENNEDY, 400 mi southwest of the center, found 48-kn winds blowing 25-ft seas and accompanied by 36-ft swells. They were also attested to by the SOHIO INTREPID, which reported 48-kn winds in 22-ft swells northwest of the center and the UNIVERSE PORTUGAL to the southwest where winds were blowing at 45 kn and seas were running 15 ft. Even farther to the southwest, swells were running 18 to 20 ft. Conditions were also rough in the eastern semicircle. The SHIN

HONSHU MARU, 250 mi to the northeast ran into 53-kn winds. Similar to other storms this month, the LOW began to recurve toward the Alaska Peninsula on the 19th. The system also began to fill. At 1200 the PRIVIV, some 300 mi to the south of the center, was hit by 50-kn winds in 25-ft seas. By the 21st the system had moved across the Alaska Peninsula to finish up in Bristol Bay.

A short wave trough was moving around the south side of a LOW centered south of the Rat Islands. A closed circulation developed in the trough as the parent LOW split into two centers on the 16th. The ASIA BEAUTY was west of the center with 47-kn winds, but her main concern was the 28-ft swells. The EXPORT COURIER measured 50-kn winds 300 mi south of the 986-mb center. On the 17th the JAPAN ERICA, about 500 mi out in the south-southwest quadrant, was sailing into 33-ft swells. High swells up to 33 ft continued through the 19th in a band about 600 mi south of the center. The winds were generally in the mid 40's. The PHILADELPHIA, just north of the center at 0600, had 55-kn northeasterly winds and measured 976.5 mb. The LOW was absorbed by another on the 20th.

The northern Gulf of Alaska was the scene of a strong northerly flow that produced a solid week of persistent gales. The culprit was the strong gradient between a large Siberian HIGH and a series of weak low-pressure systems that moved along the Aleutian Chain. It started on about the 19th when an environmental buoy radioed northerly winds at 38 kn with 15-ft seas near 59.5°N, 177.6°W. The buoy came back with 52 kn the following day after the UFEF encountered 42-kn northerlies. Winds in this area from 59° to 61°N just on either side of 180° ranged from 35 to 55 kn for the next week. Ships caught in these gales included the CAPE MAGDALENA, PRIOZERSK, MAIKI, NOVAYA KAKHOVKA, SAKHALINSKIE GORY, SOVIETSKAYA SIBIR, LESOGORSK, VOSKHOD, and the BIKINE. Many of these ships are part of the Soviet fishing fleet. Air temperatures were running -5°C to -15°C with the resultant wind-chill factors to near -45°C, and the potential for superstructure icing was quite high. Reports of 50 to 55 kn were common on the 22d and 23d. Then on the 24th the buoy radioed northerly winds at 62 kn, which was later substantiated by the OREL. Winds of 40 to 60 kn, creating frigid fishing conditions, continued through the day. They began to slacken somewhat on the 25th, but there were still some reports in the 40- to 50-kn range. Conditions continued to improve in these seas.

Near the International Dateline at about 47°N, a storm came to life on the 25th. The winds were already as high as 40 kn and waves up to 25 ft. At 1800 the MAYA PIONEER measured 55-kn winds and 41-ft seas 300 mi south of the center. The pressure fell to 974 mb the following day as conditions worsened to the south. The EATON GLORIA encountered 55-kn winds in 18-ft seas about 420 mi south of the center. Swells were running 18 to 22 ft in gales even farther to the south. The MAYA PIONEER was on a southerly track taking waves which were now as high as 46 ft on her stern. The storm moved eastward, and on the 27th the 959-mb LOW was centered near 52°N, 155°W, at 0000. The PESTOVO and the UIVD encountered 50-kn northerlies some 300 to 400 mi northwest of the center, which turned northward and began to fill. However, 50-kn winds were reported throughout the day, and at 0000 on the 28th, the 5ZLB ran into 60-kn northwesterlies in 12-ft seas about 300 mi west of the center. The PRESIDENT JEFFERSON, the same distance to the south, was blasted by 50-kn winds in 25-ft swells. On the 29th the system deteriorated rapidly.

Tropical Cyclones--Tropical storm Nora developed in the Philippine Sea just east of Samar on the 3d. Moving westward, the tropical storm moved into the central Philippines the following day. This inhibited further intensification as maximum winds reached 55 kn during the day. The system weakened as it recurved to the northeast. Nora dissipated as she passed south of Manila and back out into the Philippine Sea.

Tropical storm Opal popped up on the 9th about midway between Luzon and the northern Marianas. Winds near the center of this short-lived storm reached 40 kn as it moved east-northeastward. By the 10th Opal was a tropical depression and was in the process of becoming extratropical.

Casualties--Another log ship sank on the 1st near 02.9°N, 111.2°E, after an encounter with heavy weather. The crew of the 2,629-ton ASTER was rescued. The Indonesian ship PERHUTANII (663 tons) sank in heavy weather about 2 mi from Horsburgh Light on the 9th. Four of the crew died, and three were missing. In a collision in dense fog in San Francisco Bay near the Richmond-San Rafael Bridge, the 14,479-ton Swedish freighter DON CARLOS sustained damage above her waterline and had to be towed to Richmond. The CHESTER HARDING, the other vessel involved in the accident, was heavily damaged and towed to Alameda. No injuries were reported aboard either ship.

The Panamanian ship DEMEDER was lost in the seas south of Kyushu on the 26th. A distress call from the ship indicated a big crack had developed in the hull and it was sinking in rough seas. An extensive air-sea search was conducted, but the only clues to the fate of the 22 crewmen were an oil slick and two unmanned rubber boats found about 7 mi north-northeast of Yaku Island. That same day the 812-ton Japanese sand carrier NIKKO MARU No. 21 capsized in heavy weather in the Bungo Channel near Mikomoto Island. The crew was safe.

Principal Tracks of Centers of Cyclones at Sea Level, North Atlantic

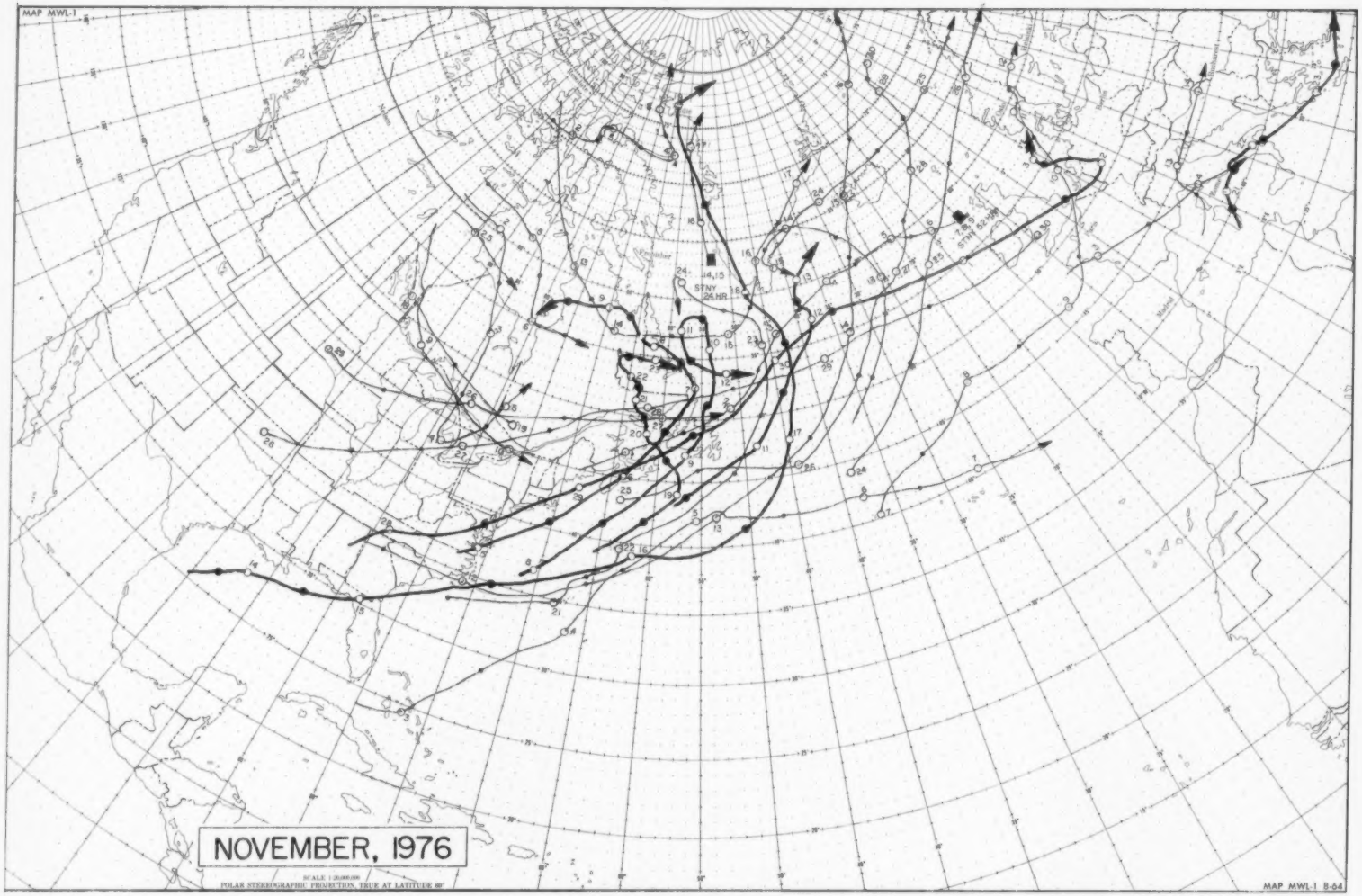


Figure 57. --Open circle indicates 1200 GMT position and closed circle 0000 GMT position. Square indicates stationary center. Cyclone tracks marked with a heavy line are described in the Smooth Log.

Principal Tracks of Centers of Cyclones at Sea Level, North Atlantic

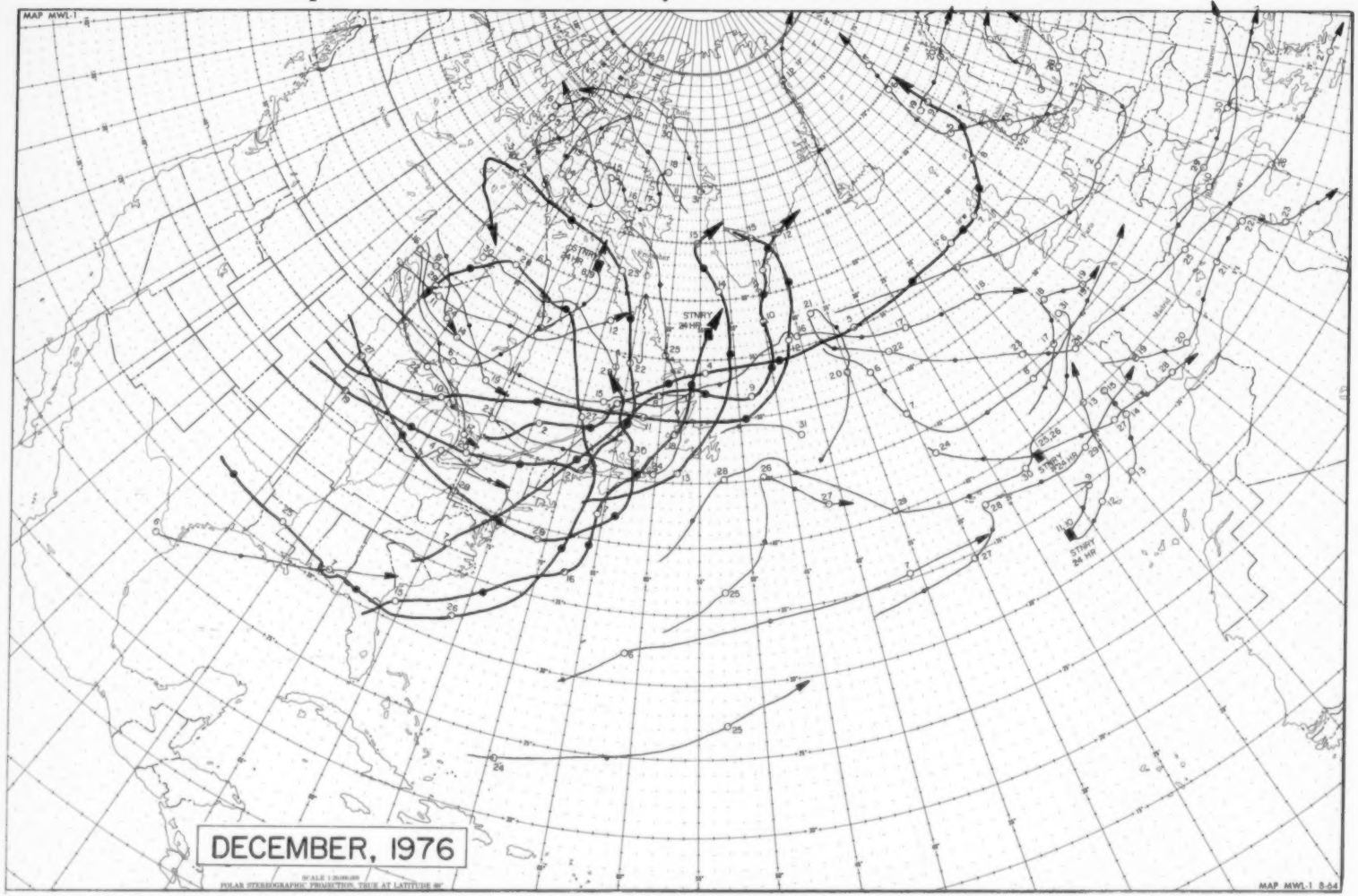


Figure 58. --Open circle indicates 1200 GMT position and closed circle 0000 GMT position. Square indicates stationary center. Cyclone tracks marked with a heavy line are described in the Smooth Log.

Principal Tracks of Centers of Cyclones at Sea Level, North Pacific

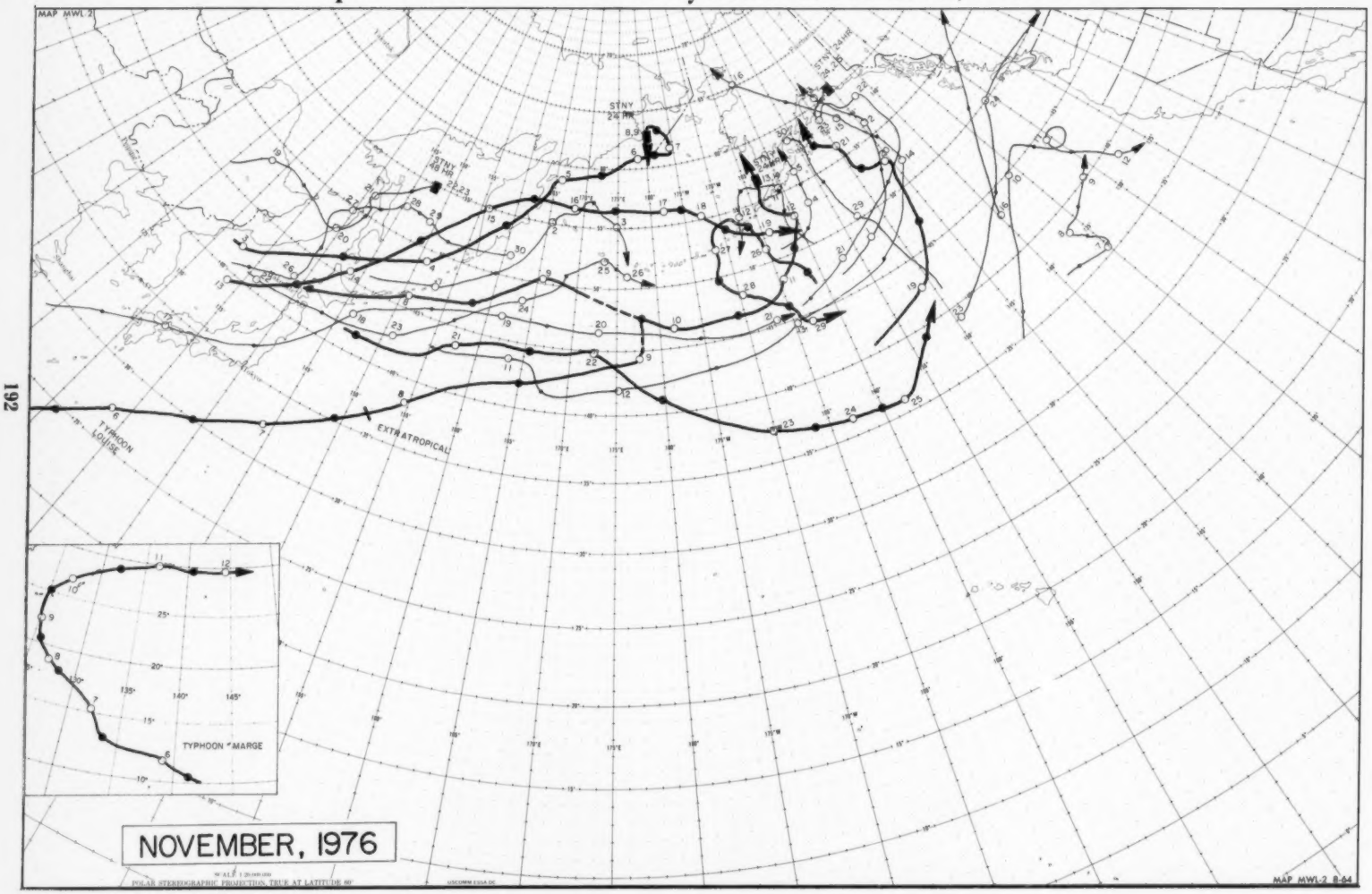


Figure 59. --Open circle indicates 1200 GMT position and closed circle 0000 GMT position. Square indicates stationary center. Cyclone tracks marked with a heavy line are described in the Smooth Log.

Principal Tracks of Centers of Cyclones at Sea Level, North Pacific

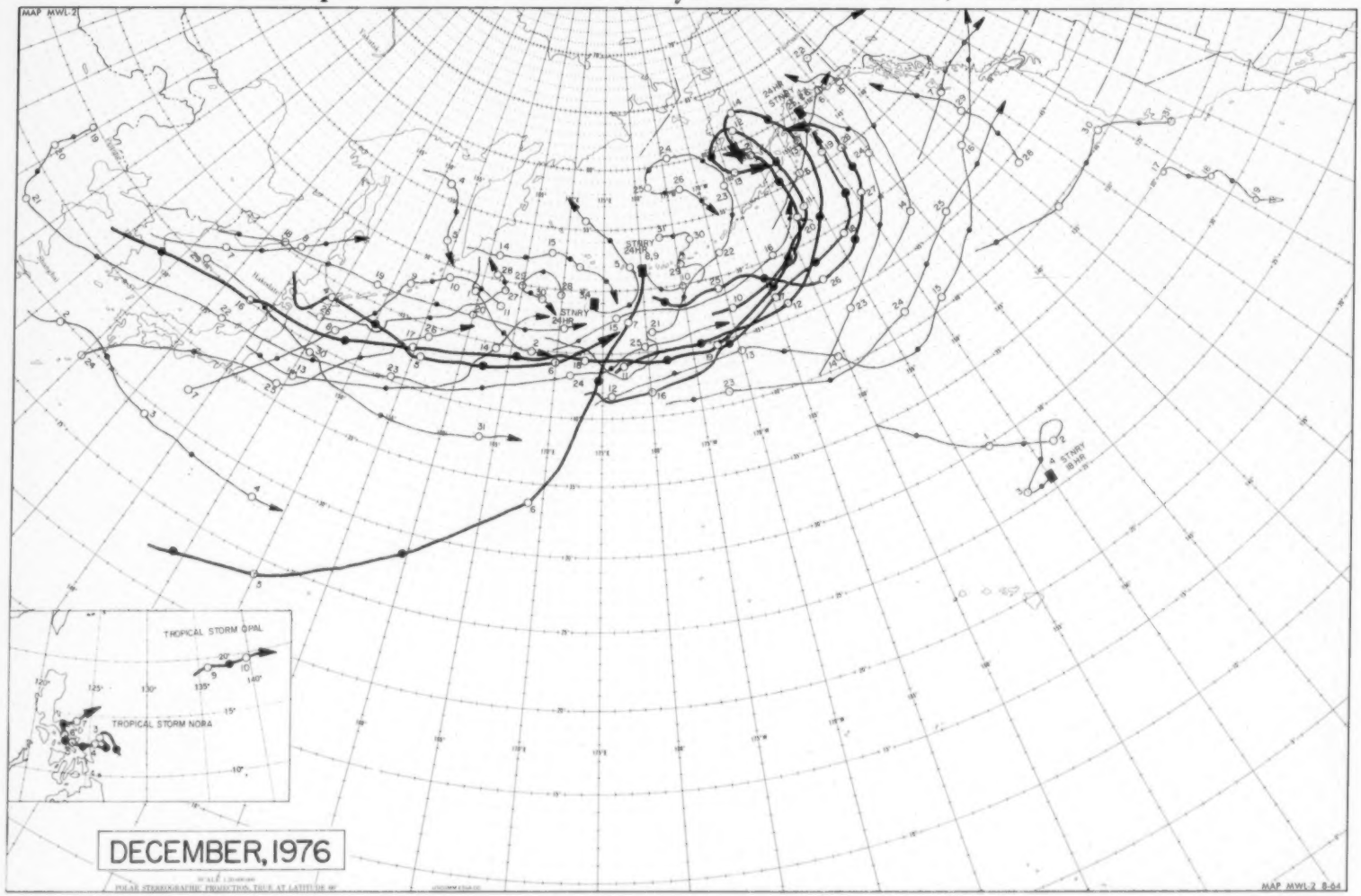


Figure 60. --Open circle indicates 1200 GMT position and closed circle 0000 GMT position. Square indicates stationary center. Cyclone tracks marked with a heavy line are described in the Smooth Log.

Table 17
U. S. Ocean Weather Station Climatological Data, North Atlantic

Ocean Weather Station 'HOTEL' 38°00'N 71°00'W November and December, 1976

MEANS AND EXTREMES

MONTH	DRY BULB TEMP (°C) MIN	DA HR	MEAN	MAX	DA HR	DEW-POINT TEMP (°C) MIN	DA HR	MEAN	MAX	DA HR	SEA TEMP (°C) MIN	DA HR	MEAN	MAX	DA HR	AIR-SEA TEMP DIFFERENCE (°C) MIN	DA HR	MEAN	MAX	DA HR
NOV	5.0	30 18	12.7	27.2	29 12	- 2.8	30 18	6.3	19.9	29 12	15.1	*28 06	19.0	25.0	09 18	-15.9	*09 18	- 6.4	2.7	28 03
DEC	.5	22 00	10.1	20.2	*07 18	- 5.0	14 12	4.8	17.8	07 21	13.2	27 06	16.8	23.1	*07 18	-16.9	03 18	- 6.8	2.8	20 21

MONTH	MEANS AND EXTREMES PRESSURE (MB) MIN	DA HR	MEAN	MAX	DA HR	PERCENTAGE FREQUENCY OF CLOUD AMOUNT (OKTAS) TOTAL CLOUD 0-2	3-5	6-7	8 & OBSC	LOW CLOUD 0-2	3-5	6-7	8 & OBSC	DAYS WITH SPECIFIED WEATHER RAIN OR DRZL PCPN	SNOW	TSTM	VSBY <1KM **	WIND (KTS) ≥34	≥48	≥64	COMP OR DAYS	OBS WITH PCPN	NO OF OBS
NOV	998.9	20 03	1014.8	1025.4	*03 06	14.6	15.4	38.8	31.3	30.0	26.7	33.8	9.6	21	21	0	0	0	6	3	0	30	13.8	240
DEC	988.0	26 21	1013.5	1039.4	10 12	6.9	16.1	40.7	36.3	18.1	37.1	31.9	12.9	23	23	7	2	0	14	5	1	31	24.2	248

** VV=80-99 AND OR 6-4 COMP OR DAYS=COMPLETE OB DAYS

Wind

NOV WIND DIRECTIONS AND SPEEDS (% FREQUENCIES)

DIR	WIND SPEED (KNOTS) <4	4-10	11-21	22-33	34-47	>47	TOTAL	MEAN SPEED
N	.0	3.5	7.0	2.0	.9	.0	8.4	16.7
NE	.0	1.0	.9	.4	.0	.0	2.4	13.5
E	.0	.8	.7	.0	.0	.0	1.6	10.0
SE	.0	.4	.3	.0	.0	.0	.7	10.5
S	.0	.7	3.8	.0	.0	.0	4.3	15.0
SW	.0	1.7	5.0	1.0	.0	.0	8.9	16.8
W	.4	4.2	10.4	12.8	2.1	.0	29.9	20.7
NW	.0	3.9	16.3	16.9	6.8	.0	43.8	23.5
CALM	.4	.0	.0	.0	.0	.0	.4	.0
TOTAL	.8	16.3	39.2	34.0	9.2	.0	100.0	20.5

NUMBER OF OBS 240 | MAX WIND DIR 330 SPEED 56 DA HR 08 2340 | VECTOR SPEED 16.1 | MEAN DIR 297 | (DIR IN DEGREES)

DEC WIND DIRECTIONS AND SPEEDS (% FREQUENCIES)

DIR	WIND SPEED (KNOTS) <4	4-10	11-21	22-33	34-47	>47	TOTAL	MEAN SPEED
N	.0	2.3	8.8	3.4	1.0	.0	15.5	18.8
NE	.4	3.4	2.8	1.4	.0	.0	8.1	13.3
E	.0	.3	1.1	1.4	.0	.0	2.8	19.5
SE	.8	.1	.0	.8	.1	.0	1.8	15.7
S	.3	2.2	.3	1.3	1.1	.6	5.8	22.1
SW	.1	1.3	2.9	4.6	.4	.0	9.6	19.7
W	.0	1.0	9.8	7.5	2.5	.4	21.2	22.7
NW	.4	2.0	8.1	16.4	9.0	.0	34.0	26.9
CALM	1.2	.0	.0	.0	.0	.0	1.2	.0
TOTAL	3.2	12.9	31.9	37.1	14.1	.8	100.0	22.0

NUMBER OF OBS 248 | MAX WIND DIR 290 SPEED 78 DA HR 07 2320 | VECTOR SPEED 13.7 | MEAN DIR 305 | (DIR IN DEGREES)

Wave

NOV WAVE DIRECTIONS AND HEIGHTS (% FREQUENCIES)

DIR	WAVE HEIGHT (METERS) <1	1-1.5	2-2.5	3-3.5	4-5.5	6-7.5	8-9.5	>9.5	TOTAL
N	.0	1.1	2.3	1.1	1.1	.0	.0	.0	5.7
NE	.0	.4	.0	.0	.0	.0	.0	.0	.4
E	.0	.4	1.1	.0	.0	.0	.0	.0	1.6
SE	.0	2.0	1.5	.0	.0	.0	.0	.0	4.1
S	.4	1.9	2.6	.6	.4	.0	.0	.0	5.9
SW	.4	2.0	2.9	1.8	.4	.0	.0	.0	7.9
W	.0	5.0	7.6	7.3	4.0	.0	.0	.0	29.9
NW	.8	8.9	13.2	11.5	7.0	2.5	.0	.0	43.9
IND	.0	3.3	1.7	.8	.8	.0	.0	.0	6.7
CALM	.0	.0	.0	.0	.0	.0	.0	.0	.0
TOTAL	1.7	26.3	32.9	22.9	13.8	2.5	.0	.0	100.0

NUMBER OF OBS 240 IND=INDETERMINATE

DEC WAVE DIRECTIONS AND HEIGHTS (% FREQUENCIES)

DIR	WAVE HEIGHT (METERS) <1	1-1.5	2-2.5	3-3.5	4-5.5	6-7.5	8-9.5	>9.5	TOTAL
N	.8	8.8	4.0	.7	1.8	.0	.0	.0	16.1
NE	.4	2.8	1.6	.0	.0	.0	.0	.0	4.4
E	.0	.8	1.8	.7	.0	.0	.0	.0	3.3
SE	.0	.8	.0	.9	.1	.0	.0	.0	1.8
S	.8	1.6	.7	.8	1.9	.4	.0	.0	6.3
SW	.4	5.7	5.3	1.2	.0	.5	.0	.0	13.2
W	.0	4.7	2.6	1.0	3.7	.6	.0	.0	12.7
NW	1.2	4.1	9.5	8.0	14.6	.5	.0	.0	37.9
IND	.0	3.2	.0	1.2	.0	.0	.0	.0	4.4
CALM	.0	.0	.0	.0	.0	.0	.0	.0	.0
TOTAL	3.6	32.3	25.4	14.5	22.2	2.0	.0	.0	100.0

NUMBER OF OBS 248 IND=INDETERMINATE

NOV WAVE PERIODS AND HEIGHTS (% FREQUENCIES)

PERIOD IN SECONDS	WAVE HEIGHT (METERS) <1	1-1.5	2-2.5	3-3.5	4-5.5	6-7.5	8-9.5	>9.5	TOTAL
<6	1.3	10.8	8.8	.0	.0	.0	.0	.0	20.8
6-7	.4	7.5	17.1	17.9	7.1	.0	.0	.0	50.0
8-9	.0	4.6	5.0	4.2	5.8	2.5	.0	.0	22.1
10-11	.0	.0	.4	.0	.0	.0	.0	.0	.4
12-13	.0	.0	.0	.0	.0	.0	.0	.0	.0
>13	.0	.0	.0	.0	.0	.0	.0	.0	.0
IND	.0	3.3	1.7	.8	.8	.0	.0	.0	6.7
TOTAL	1.7	26.3	32.9	22.9	13.8	2.5	.0	.0	100.0

NUMBER OF OBS 240 | MAX WAVE HEIGHT HGT 7.0 PER 9 DIR 300 TYPE SEA DA HR 09 09 | IND=INDETERMINATE (DIR IN DEGREES)

*ALSO OCCURRED ON PREVIOUS OBSERVATIONS

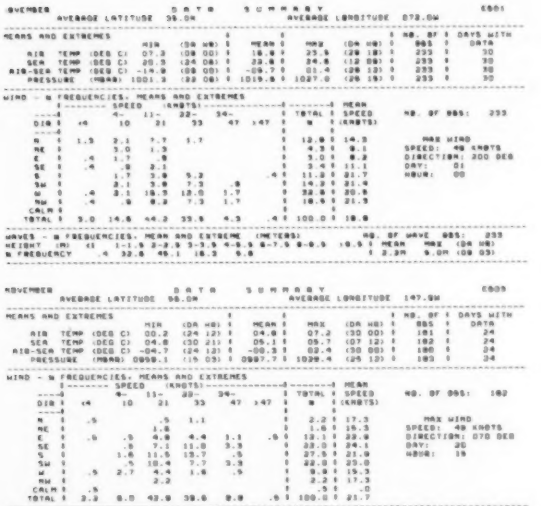
DEC WAVE PERIODS AND HEIGHTS (% FREQUENCIES)

PERIOD IN SECONDS	WAVE HEIGHT (METERS) <1	1-1.5	2-2.5	3-3.5	4-5.5	6-7.5	8-9.5	>9.5	TOTAL
<6	1.6	18.5	13.7	.4	2.0	.0	.0	.0	36.3
6-7	2.0	10.5	8.5	8.5	9.7	.4	.0	.0	39.5
8-9	.0	.0	3.2	4.4	10.5	1.6	.0	.0	19.8
10-11	.0	.0	.0	.0	.0	.0	.0	.0	.0
12-13	.0	.0	.0	.0	.0	.0	.0	.0	.0
>13	.0	.0	.0	.0	.0	.0	.0	.0	.0
IND	.0	3.2	.0	1.2	.0	.0	.0	.0	4.4
TOTAL	3.6	32.3	25.4	14.5	22.2	2.0	.0	.0	100.0

NUMBER OF OBS 248 | MAX WAVE HEIGHT HGT 7.0 PER 9 DIR 290 TYPE SEA DA HR 08 00 | IND=INDETERMINATE (DIR IN DEGREES)

For each observation, the higher wave of the sea swell group was selected for summarization. If heights were equal, the wave with the longer period was selected. If periods were also equal, the sea wave was used.

Table 18
U. S. Ocean Buoy Climatological Data
November and December 1976



NOVEMBER — DATA SUMMARY — 46001
AVERAGE LATITUDE 50.0N — AVERAGE LONGITUDE 172.0W

MEANS AND EXTREMES

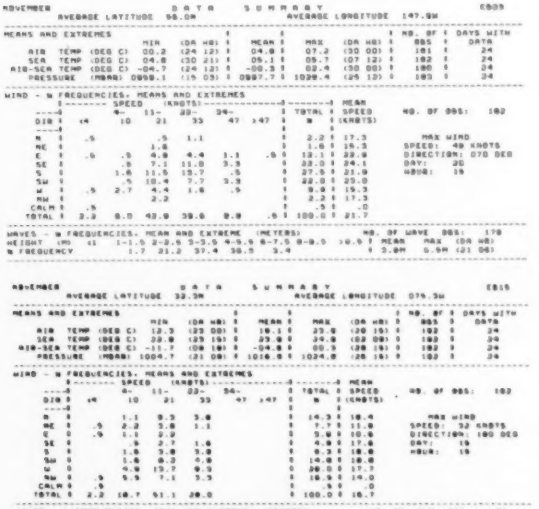
	MIN	(DA HR)	MEAN	MAX	(DA HR)	NO. OF OBS	DAYS WITH DATA
AIR TEMP (DEG C)	07.3	(08 00)	10.9	25.5	(29 18)	233	30
SEA TEMP (DEG C)	09.5	(24 06)	10.8	24.8	(12 09)	233	30
AIR-SEA TEMP (DEG C)	-14.9	(08 00)	-00.7	01.4	(28 12)	233	30
PRESSURE (MBAR)	1001.3	(22 06)	1019.9	1027.0	(26 19)	259	30

WIND - % FREQUENCIES, MEANS AND EXTREMES

SPEED (KNOTS)						MEAN		
	4-	11-	22-	34-		TOTAL	SPEED	NO. OF OBS: 233
DIR	<4	10	21	33	47 >47	%	(KNOTS)	
N	1.3	2.1	7.7	1.7		12.9	14.3	MAX WIND
NE		3.0	1.3			4.3	9.1	SPEED: 48 KNOTS
E	.4	1.7	.9			3.0	8.2	DIRECTION: 300 DEG
SE	.4	.9	2.1			3.4	11.1	DAY: 01
S		1.7	3.9	5.2	.4	11.2	21.7	HOUR: 00
SW		2.1	5.8	7.3	.9	14.2	21.4	
W	.4	2.1	10.3	12.0	1.7	32.6	20.8	
NW	.4	.9	8.2	7.3	1.7	18.4	21.5	
CALM								
TOTAL	3.0	14.6	44.2	35.6	4.3	100.0	18.8	

WAVES - % FREQUENCIES, MEAN AND EXTREME (METERS) — NO. OF WAVE OBS: 233

HEIGHT (M)	<1	1-1.5	2-2.5	3-3.5	4-4.5	5-7.5	8-9.5	>9.5	MEAN	MAX (DA HR)
% FREQUENCY	.4	32.6	46.1	18.3	2.6				2.3M	9.0M (09 03)



NOVEMBER — DATA SUMMARY — 46003
AVERAGE LATITUDE 56.0N — AVERAGE LONGITUDE 147.9W

MEANS AND EXTREMES

	MIN	(DA HR)	MEAN	MAX	(DA HR)	NO. OF OBS	DAYS WITH DATA
AIR TEMP (DEG C)	00.2	(24 12)	04.8	07.2	(30 00)	181	24
SEA TEMP (DEG C)	04.8	(30 21)	05.1	05.7	(07 12)	182	24
AIR-SEA TEMP (DEG C)	-04.7	(24 12)	-00.3	02.4	(30 00)	180	24
PRESSURE (MBAR)	0958.1	(15 03)	0987.7	1029.4	(25 12)	183	24

WIND - % FREQUENCIES, MEANS AND EXTREMES

SPEED (KNOTS)						MEAN		
	4-	11-	22-	34-		TOTAL	SPEED	NO. OF OBS: 182
DIR	<4	10	21	33	47 >47	%	(KNOTS)	
N	.5		.5	1.1		2.2	17.3	MAX WIND
NE			1.6			1.6	15.3	SPEED: 48 KNOTS
E	.5	.5	3.8	4.4	1.1	10.1	20.8	DIRECTION: 070 DEG
SE		.5	7.1	11.0	3.3	23.0	24.1	DAY: 25
S		1.6	11.0	13.7	.5	27.0	23.0	HOUR: 19
SW		.5	10.4	7.7	3.3	22.0	25.0	
W	.5	2.7	4.4	1.6	.5	9.9	19.3	
NW			2.2			2.2	17.3	
CALM	.5					.5	.0	
TOTAL	2.2	6.0	42.0	38.6	8.8	100.0	21.7	

WAVES - % FREQUENCIES, MEAN AND EXTREME (METERS) — NO. OF WAVE OBS: 178

HEIGHT (M)	<1	1-1.5	2-2.5	3-3.5	4-4.5	5-7.5	8-9.5	>9.5	MEAN	MAX (DA HR)
% FREQUENCY		1.7	21.2	37.4	30.5	9.4			3.0M	6.5M (21 06)

NOVEMBER — DATA SUMMARY — 46035
AVERAGE LATITUDE 32.3N — AVERAGE LONGITUDE 079.3W

MEANS AND EXTREMES

	MIN	(DA HR)	MEAN	MAX	(DA HR)	NO. OF OBS	DAYS WITH DATA
AIR TEMP (DEG C)	12.3	(25 00)	18.1	25.9	(20 15)	182	24
SEA TEMP (DEG C)	20.8	(25 15)	23.0	24.9	(02 09)	182	24
AIR-SEA TEMP (DEG C)	-11.7	(09 18)	-04.8	00.3	(28 15)	182	24
PRESSURE (MBAR)	1004.7	(21 09)	1016.9	1024.0	(28 16)	182	24

WIND - % FREQUENCIES, MEANS AND EXTREMES

SPEED (KNOTS)						MEAN		
	4-	11-	22-	34-		TOTAL	SPEED	NO. OF OBS: 182
DIR	<4	10	21	33	47 >47	%	(KNOTS)	
N		1.1	9.3	3.8		14.3	18.4	MAX WIND
NE	.5	2.2	3.8	1.1		7.7	21.0	SPEED: 52 KNOTS
E	.5	1.1	2.2			3.8	10.8	DIRECTION: 180 DEG
SE		.5	2.7	1.6		4.9	17.8	DAY: 19
S		1.6	3.8	3.8	.5	9.9	18.8	HOUR: 19
SW		1.6	8.2	6.0		14.8	18.8	
W		4.9	19.7	9.3		33.9	17.7	
NW	.5	1.1	5.5	1.1		8.2	14.0	
CALM	.5					.5	.0	
TOTAL	2.2	10.7	51.1	28.0		100.0	18.7	

WAVES - % FREQUENCIES, MEAN AND EXTREME (METERS) — NO. OF WAVE OBS: 182

HEIGHT (M)	<1	1-1.5	2-2.5	3-3.5	4-4.5	5-7.5	8-9.5	>9.5	MEAN	MAX (DA HR)
% FREQUENCY	5.5	56.0	34.6	3.3					1.6M	3.0M (22 15)

NOVEMBER — DATA SUMMARY — 46036
AVERAGE LATITUDE 48.5N — AVERAGE LONGITUDE 138.0W

MEANS AND EXTREMES

	MIN	(DA HR)	MEAN	MAX	(DA HR)	NO. OF OBS	DAYS WITH DATA
AIR TEMP (DEG C)	11.9	(21 06)	14.1	16.1	(02 12)	240	30
SEA TEMP (DEG C)	14.8	(28 15)	15.4	16.1	(04 00)	238	30
AIR-SEA TEMP (DEG C)	-03.6	(21 06)	-01.3	01.8	(30 18)	238	30
PRESSURE (MBAR)	0980.5	(11 00)	1018.1	1030.8	(28 18)	240	30

WIND - % FREQUENCIES, MEANS AND EXTREMES

SPEED (KNOTS)						MEAN		
	4-	11-	22-	34-		TOTAL	SPEED	NO. OF OBS: 240
DIR	<4	10	21	33	47 >47	%	(KNOTS)	
N	.4	6.7	9.3			13.3	10.4	MAX WIND
NE	.4	3.8	12.1	3.3		19.6	15.3	SPEED: 41 KNOTS
E		2.5	5.4	.8		8.8	14.1	DIRECTION: 260 DEG
SE	.4	1.7	3.3	.8		6.3	14.8	DAY: 19
S	.4	3.9	17.8	3.8		25.8	15.8	HOUR: 03
SW	1.3	.8	9.4	4.2	.4	16.2	19.2	
W	.4	1.3	3.3	.8	.8	6.6	18.0	
NW	1.3	1.3	3.3			5.8	9.8	
CALM								
TOTAL	4.8	21.7	58.8	13.8	1.3	100.0	14.8	

WAVES - % FREQUENCIES, MEAN AND EXTREME (METERS) — NO. OF WAVE OBS: 240

HEIGHT (M)	<1	1-1.5	2-2.5	3-3.5	4-4.5	5-7.5	8-9.5	>9.5	MEAN	MAX (DA HR)
% FREQUENCY		15.4	50.0	15.8	7.9	1.3			2.5M	6.5M (14 08)

NOVEMBER — DATA SUMMARY — 46037
AVERAGE LATITUDE 52.0N — AVERAGE LONGITUDE 148.0W

MEANS AND EXTREMES

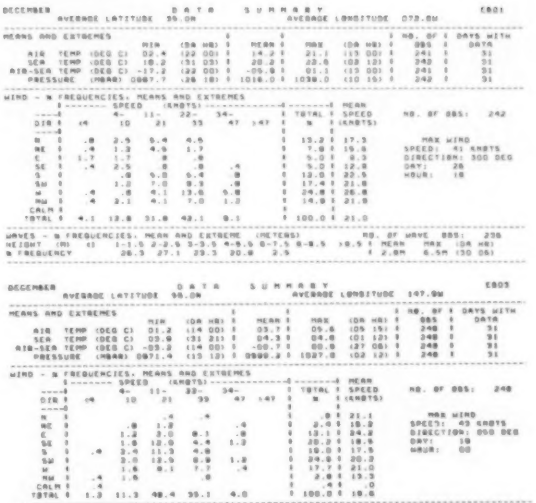
	MIN	(DA HR)	MEAN	MAX	(DA HR)	NO. OF OBS	DAYS WITH DATA
AIR TEMP (DEG C)	-01.7	(03 15)	03.8	07.1	(07 15)	238	30
SEA TEMP (DEG C)	05.4	(30 21)	05.9	06.4	(01 00)	234	30
AIR-SEA TEMP (DEG C)	-07.7	(02 15)	-01.5	02.0	(28 09)	234	30
PRESSURE (MBAR)	0975.8	(12 12)	0999.3	1027.1	(24 21)	237	30

WIND - % FREQUENCIES, MEANS AND EXTREMES

SPEED (KNOTS)						MEAN		
	4-	11-	22-	34-		TOTAL	SPEED	NO. OF OBS: 237
DIR	<4	10	21	33	47 >47	%	(KNOTS)	
N		1.3	2.5	3.0		6.8	16.0	MAX WIND
NE		.4	1.3	.4		2.1	15.8	SPEED: 41 KNOTS
E	.4	.8	3.4	2.5	1.3	8.4	21.1	DIRECTION: 070 DEG
SE		1.3	3.8	5.0	.8	11.0	22.1	DAY: 25
S	.8	3.4	7.6	4.2		16.2	19.8	HOUR: 21
SW		4.2	12.2	8.5		22.8	17.1	
W		2.5	10.8	9.3		22.7	18.2	
NW	.4		2.1	.4		2.9	20.1	
CALM								
TOTAL	1.7	13.5	52.3	33.0	2.6	100.0	18.4	

WAVES - % FREQUENCIES, MEAN AND EXTREME (METERS) — NO. OF WAVE OBS: 234

HEIGHT (M)	<1	1-1.5	2-2.5	3-3.5	4-4.5	5-7.5	8-9.5	>9.5	MEAN	MAX (DA HR)
% FREQUENCY		3.0	30.4	43.4	23.0	0			3.2M	8.0M (11 18)



DECEMBER — DATA SUMMARY — 46001
AVERAGE LATITUDE 50.0N — AVERAGE LONGITUDE 172.0W

MEANS AND EXTREMES

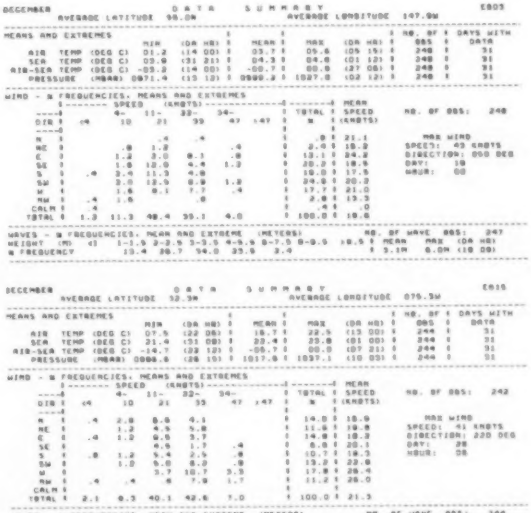
	MIN	(DA HR)	MEAN	MAX	(DA HR)	NO. OF OBS	DAYS WITH DATA
AIR TEMP (DEG C)	02.4	(22 00)	14.2	21.1	(15 00)	241	31
SEA TEMP (DEG C)	10.2	(31 03)	20.2	22.8	(02 12)	242	31
AIR-SEA TEMP (DEG C)	-17.2	(22 00)	-05.9	01.1	(15 00)	241	31
PRESSURE (MBAR)	0987.7	(26 18)	1016.0	1038.0	(10 15)	242	31

WIND - % FREQUENCIES, MEANS AND EXTREMES

SPEED (KNOTS)						MEAN		
	4-	11-	22-	34-		TOTAL	SPEED	NO. OF OBS: 242
DIR	<4	10	21	33	47 >47	%	(KNOTS)	
N	.8	2.5	5.4	4.6		13.2	17.5	MAX WIND
NE	.4	1.2	4.6	1.7		7.8	15.6	SPEED: 41 KNOTS
E	1.2	1.7	.8			3.8	8.3	DIRECTION: 300 DEG
SE	.4	2.5	.8	.8	.4	5.0	12.8	DAY: 26
S		.8	5.0	6.2	.8	12.8	22.5	HOUR: 18
SW		1.2	7.0	9.5	.8	17.4	21.6	
W	.4	.8	4.1	13.6	5.8	24.8	26.8	
NW	.4	2.1	2.5	7.0	1.2	14.8	21.0	
CALM								
TOTAL	4.1	12.8	31.8	42.1	9.1	100.0	21.0	

WAVES - % FREQUENCIES, MEAN AND EXTREME (METERS) — NO. OF WAVE OBS: 236

HEIGHT (M)	<1	1-1.5	2-2.5	3-3.5	4-4.5	5-7.5	8-8.5	>8.5	MEAN	MAX (DA HR)
% FREQUENCY		26.3	27.1	23.3	20.8	2.5			2.8M	6.5M (30 06)



DECEMBER — DATA SUMMARY — 46003
AVERAGE LATITUDE 56.0N — AVERAGE LONGITUDE 147.9W

MEANS AND EXTREMES

	MIN	(DA HR)	MEAN	MAX	(DA HR)	NO. OF OBS	DAYS WITH DATA
AIR TEMP (DEG C)	01.2	(14 00)	03.7	05.6	(09 15)	248	31
SEA TEMP (DEG C)	03.6	(31 21)	04.3	04.8	(01 12)	248	31
AIR-SEA TEMP (DEG C)	-03.2	(14 00)	-00.7	00.8	(27 06)	248	31
PRESSURE (MBAR)	0971.4	(13 12)	0998.2	1027.8	(02 12)	248	31

WIND - % FREQUENCIES, MEANS AND EXTREMES

SPEED (KNOTS)						MEAN		
	4-	11-	22-	34-		TOTAL	SPEED	NO. OF OBS: 248
DIR	<4	10	21	33	47 >47	%	(KNOTS)	
N			.4	.4		.8	21.1	MAX WIND
NE		.8	1.2		.4	2.0	18.2	SPEED: 49 KNOTS
E		1.2	3.0	8.1	.8	13.1	24.2	DIRECTION: 050 DEG
SE		1.6	12.9	4.4	1.2	20.2	18.9	DAY: 19
S	.4	3.6	15.3	7.3		26.6	17.5	HOUR: 00
SW		3.0	12.9	8.9	1.2	26.0	20.2	
W		1.6	8.1	7.7	.4	17.7	21.0	
NW	.4	1.6		.8		2.8	13.3	
CALM	.4					.4	.0	
TOTAL	1.2	11.3	48.4	35.1	4.0	100.0	19.8	

WAVES - % FREQUENCIES, MEAN AND EXTREME (METERS) — NO. OF WAVE OBS: 247

HEIGHT (M)	<1	1-1.5	2-2.5	3-3.5	4-4.5	5-7.5	8-9.5	>9.5	MEAN	MAX (DA HR)
% FREQUENCY		13.4	28.7	34.0	23.5	2.4			3.1M	8.0M (18 09)

DECEMBER — DATA SUMMARY — 46035
AVERAGE LATITUDE 32.3N — AVERAGE LONGITUDE 079.3W

MEANS AND EXTREMES

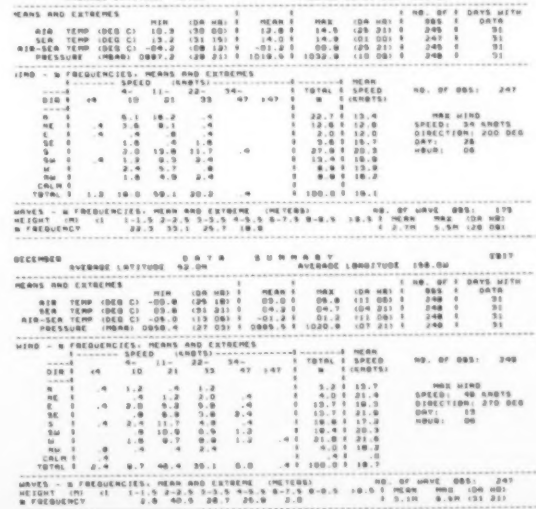
	MIN	(DA HR)	MEAN	MAX	(DA HR)	NO. OF OBS	DAYS WITH DATA
AIR TEMP (DEG C)	07.5	(22 06)	18.7	22.5	(13 00)	244	31
SEA TEMP (DEG C)	21.1	(31 03)	22.4	23.8	(01 00)	244	31
AIR-SEA TEMP (DEG C)	-14.7	(22 12)	-03.7	00.0	(07 21)	244	31
PRESSURE (MBAR)	0988.8	(26 10)	1017.8	1037.1	(10 03)	244	31

WIND - % FREQUENCIES, MEANS AND EXTREMES

SPEED (KNOTS)						MEAN		
	4-	11-	22-	34-		TOTAL	SPEED	NO. OF OBS: 242
DIR	<4	10	21	33	47 >47	%	(KNOTS)	
N	.4	2.9	6.6	4.1		14.0	18.9	MAX WIND
NE		.8	1.2	.8		11.9	19.8	SPEED: 41 KNOTS
E	.4	1.2	6.6	3.7		14.8	18.2	DIRECTION: 220 DEG
SE			6.6	1.7	.4	8.8	20.1	DAY: 28
S	.8	1.2	5.4	4.5		10.7	19.5	HOUR: 06
SW		1.2	6.6	6.0	.8	13.2	22.9	
W			3.3	10.7	3.3	17.8	26.6	
NW	.4	.4	.8	7.9	1.7	11.2	26.0	
CALM								
TOTAL	2.1	8.3	40.1	42.8	7.0	100.0	21.3	

WAVES - % FREQUENCIES, MEAN AND EXTREME (METERS) — NO. OF WAVE OBS: 244

HEIGHT (M)	<1	1-1.5	2-2.5	3-3.5	4-4.5	5-7.5	8-9.5	>9.5	MEAN	MAX (DA HR)
% FREQUENCY	2.9	32.0	41.0	19.8	4.2				2.2M	4.5M (29 09)



DECEMBER — DATA SUMMARY — 46036
AVERAGE LATITUDE 48.5N — AVERAGE LONGITUDE 138.0W

MEANS AND EXTREMES

	MIN	(DA HR)	MEAN	MAX	(DA HR)	NO. OF OBS	DAYS WITH DATA
AIR TEMP (DEG C)	10.9	(30 00)	12.8	14.5	(25 21)	248	31
SEA TEMP (DEG C)	13.2	(31 15)	14.0	14.9	(01 00)	247	31
AIR-SEA TEMP (DEG C)	-04.2	(08 12)	-01.2	00.8	(29 21)	245	31
PRESSURE (MBAR)	0982.2	(29 21)	1019.5	1032.9	(10 00)	248	31

WIND - % FREQUENCIES, MEANS AND EXTREMES

SPEED (KNOTS)						MEAN		
	4-	11-	22-	34-		TOTAL	SPEED	NO. OF OBS: 247
DIR	<4	10	21	33	47 >47	%	(KNOTS)	
N		5.1	15.2	.4		22.7	13.4	MAX WIND
NE	.4	3.6	8.1	.4		12.6	12.8	SPEED: 34 KNOTS
E	.4	.4	.8	.4		2.0	12.0	DIRECTION: 200 DEG
SE			1.6	1.6		3.2	16.2	DAY: 14
S		2.0	13.8	11.7	.4	27.9	20.3	HOUR: 03
SW	.4	1.2	9.3	9.3		19.4	18.9	
W		.4	3.7	6.9		11.0	19.3	
NW		1.6	4.9	2.4		8.9	18.2	
CALM								
TOTAL	1.2	18.0	59.1	30.2	.4	100.0	16.1	

WAVES - % FREQUENCIES, MEAN AND EXTREME (METERS) — NO. OF WAVE OBS: 175

HEIGHT (M)	<1	1-1.5	2-2.5	3-3.5	4-4.5	5-7.5	8-8.5	>8.5	MEAN	MAX (DA HR)
% FREQUENCY		29.3	33.1	25.7	10.9				2.1M	5.5M (28 08)

DECEMBER — DATA SUMMARY — 46037
AVERAGE LATITUDE 52.0N — AVERAGE LONGITUDE 148.0W

MEANS AND EXTREMES

	MIN	(DA HR)	MEAN	MAX	(DA HR)	NO. OF OBS	DAYS WITH DATA
AIR TEMP (DEG C)	-00.0	(29 18)	05.0	09.8	(11 00)	248	31
SEA TEMP (DEG C)	05.4	(31 21)	06.1	06.8	(01 00)	248	31
AIR-SEA TEMP (DEG C)	-05.0	(13 06)	-01.2	01.2	(11 06)	248	31
PRESSURE (MBAR)	0958.4	(27 03)	0985.5	1020.8	(07 21)	248	31

WIND - % FREQUENCIES, MEANS AND EXTREMES

SPEED (KNOTS)						MEAN		
	4-	11-	22-	34-		TOTAL	SPEED	NO. OF OBS: 249
DIR	<4	10	21	33	47 >47	%	(KNOTS)	
N	.4	1.2	.4	1.2		5.2	13.7	MAX WIND
NE			1.2	2.0	.4	4.0	21.9	SPEED: 48 KNOTS
E	.0	2.0	5.2	5.2	.4	13.7	19.3	DIRECTION: 270 DEG
SE		.8	6.5	3.6	2.4	13.7	21.9	DAY: 13
S	.4	2.4	7.7	5.2	.4	16.1	17.2	HOUR: 09
SW		.8	10.0	6.5	1.2	18.4	20.3	
W		1.6	9.7	8.9	1.2	21.8	21.6	
NW	.8	.4		2.4	.4	4.0	18.2	
CALM	.4					.4	.0	
TOTAL	2.4	8.7	40.4	35.1	5.0	100.0	19.7	

WAVES - % FREQUENCIES, MEAN AND EXTREME (METERS) — NO. OF WAVE OBS: 247

HEIGHT (M)	<1	1-1.5	2-2.5	3-3.5	4-4.5	5-7.5	8-8.5	>8.5	MEAN	MAX (DA HR)
% FREQUENCY		2.8	40.5	28.7	26.9	2.0			3.1M	9.0M (31 21)

```
NOVEMBER                    D A T A    S U M M A R Y                        E821
          AVERAGE LATITUDE  46.0N               AVERAGE LONGITUDE  131.0W
--------------------------------------------------------------------------------
MEANS AND EXTREMES                     !        !                  ! NO. OF ! DAYS WITH
                        MIN   (DA HR) !   MEAN !   MAX   (DA HR) !  OBS   !   DATA
    AIR  TEMP (DEG C)  10.1   (28 15) !   12.9 !   15.4  (02 21) !  230   !    30
    SEA  TEMP (DEG C)  12.0   (30 21) !   13.7 !   14.2  (12 00) !  230   !    30
 AIR-SEA TEMP (DEG C) -03.1   (28 12) !  -00.8 !   01.4  (02 21) !  230   !    30
    PRESSURE  (MBAR) 0992.7   (14 00) ! 1018.7 ! 1035.5  (28 18) !  230   !    30
--------------------------------------------------------------------------------
WIND - % FREQUENCIES, MEANS AND EXTREMES
        !------- SPEED   (KNOTS)-------------!-------! MEAN
   -----!           4-    11-   22-   34-      ! TOTAL ! SPEED    NO. OF OBS:   230
   DIR  !   <4     10    21    33    47  >47   !   %   !(KNOTS)
   -----!                                      !       !
   N    !          3.3   2.5                   !   5.8 ! 10.2        MAX WIND
   NE   !           .8   3.8    .4             !   5.0 ! 13.3     SPEED:  28 KNOTS
   E    !   1.3    3.8  12.6    .4             !  18.0 ! 12.1     DIRECTION: 180 DEG
   SE   !    .4    4.2  15.5   1.3             !  21.3 ! 14.2     DAY:    17
   S    !          7.1  10.8   6.3             !  24.3 ! 16.3     HOUR:   03
   SW   !    .4    5.4   7.5   1.3             !  14.8 ! 13.4
   W    !    .8     .8   3.3   1.3             !   6.3 ! 14.3
   NW   !    .4     .4   2.5   1.3             !   4.6 ! 16.5
   CALM !                                      !       !
   TOTAL!   3.3   24.8  58.6  12.1             ! 100.0 ! 14.0
--------------------------------------------------------------------------------
WAVES - % FREQUENCIES, MEAN AND EXTREME  (METERS)           NO. OF WAVE  OBS:   230
HEIGHT  (M)  <1   1-1.5 2-2.5 3-3.5 4-5.5 6-7.5 8-9.5  >9.5 ! MEAN   MAX  (DA HR)
% FREQUENCY       24.7  45.6  22.2   6.7    .8              ! 2.4M   6.0M (15 15)
--------------------------------------------------------------------------------
```

```
NOVEMBER                    D A T A    S U M M A R Y                        E834
          AVERAGE LATITUDE  40.1N               AVERAGE LONGITUDE  073.0W
--------------------------------------------------------------------------------
MEANS AND EXTREMES                     !        !                  ! NO. OF ! DAYS WITH
                        MIN   (DA HR) !   MEAN !   MAX   (DA HR) !  OBS   !   DATA
    AIR  TEMP (DEG C) -02.8   (30 18) !   08.9 !   12.2  (27 03) !  119   !    15
    SEA  TEMP (DEG C)  08.8   (28 00) !   08.8 !   10.8  (17 18) !  119   !    15
 AIR-SEA TEMP (DEG C) -11.6   (30 18) !  -02.8 !   02.8  (27 03) !  119   !    15
    PRESSURE  (MBAR) 0987.6   (20 00) ! 1012.0 ! 1029.2  (30 21) !  119   !    15
--------------------------------------------------------------------------------
WIND - % FREQUENCIES, MEANS AND EXTREMES
        !------- SPEED   (KNOTS)-------------!-------! MEAN
   -----!           4-    11-   22-   34-      ! TOTAL ! SPEED    NO. OF OBS:   114
   DIR  !   <4     10    21    33    47  >47   !   %   !(KNOTS)
   -----!                                      !       !
   N    !    .9          2.6                   !   3.5 ! 12.8        MAX WIND
   NE   !                                      !       !          SPEED:  28 KNOTS
   E    !                                      !       !          DIRECTION: 280 DEG
   SE   !    .9                                !    .9 !  2.0     DAY:    23
   S    !          1.8  14.0                   !  15.8 ! 14.5     HOUR:   08
   SW   !    .9    5.3   7.0                   !  13.2 ! 11.8
   W    !          4.4  28.1  21.1             !  53.5 ! 18.2
   NW   !          1.8   8.8   3.8             !  13.2 ! 16.4
   CALM !                                      !       !
   TOTAL!   2.6   13.2  60.5  23.7             ! 100.0 ! 16.7
--------------------------------------------------------------------------------
% OF OBS WITH POTENTIAL SUPERSTRUCTURE ICING  MODERATE: 1.8%  SEVERE: NONE #OBS:   114
```

```
NOVEMBER                    D A T A    S U M M A R Y                        E841
          AVERAGE LATITUDE  38.7N               AVERAGE LONGITUDE  073.8W
--------------------------------------------------------------------------------
MEANS AND EXTREMES                     !        !                  ! NO. OF ! DAYS WITH
                        MIN   (DA HR) !   MEAN !   MAX   (DA HR) !  OBS   !   DATA
    AIR  TEMP (DEG C) -02.5   (30 18) !   07.8 !   13.0  (27 08) !  120   !    18
    SEA  TEMP (DEG C)  10.4   (30 12) !   10.8 !   11.3  (22 03) !  120   !    18
 AIR-SEA TEMP (DEG C) -13.4   (30 18) !  -03.0 !   02.2  (27 08) !  120   !    18
    PRESSURE  (MBAR) 0988.5   (20 08) ! 1013.6 ! 1025.8  (30 15) !  120   !    18
--------------------------------------------------------------------------------
WIND - % FREQUENCIES, MEANS AND EXTREMES
        !------- SPEED   (KNOTS)-------------!-------! MEAN
   -----!           4-    11-   22-   34-      ! TOTAL ! SPEED    NO. OF OBS:   120
   DIR  !   <4     10    21    33    47  >47   !   %   !(KNOTS)
   -----!                                      !       !
   N    !                5.8                   !   5.8 ! 14.9        MAX WIND
   NE   !                                      !       !          SPEED:  28 KNOTS
   E    !                                      !       !          DIRECTION: 330 DEG
   SE   !                                      !       !          DAY:    20
   S    !          6.7  10.8                   !  17.5 ! 11.6     HOUR:   06
   SW   !    .8    7.5   8.7                   !  19.0 ! 10.8
   W    !          2.5  23.3   5.0             !  30.8 ! 17.2
   NW   !          3.3  22.5   5.8             !  31.7 ! 16.3
   CALM !                                      !       !
   TOTAL!    .8   20.0  68.3  10.8             ! 100.0 ! 14.7
--------------------------------------------------------------------------------
WAVES - % FREQUENCIES, MEAN AND EXTREME  (METERS)           NO. OF WAVE  OBS:   121
HEIGHT  (M)  <1   1-1.5 2-2.5 3-3.5 4-5.5 6-7.5 8-9.5  >9.5 ! MEAN   MAX  (DA HR)
% FREQUENCY  14.0  81.2  23.1   1.7                          ! 1.5M   5.0M (23 08)
--------------------------------------------------------------------------------
% OF OBS WITH POTENTIAL SUPERSTRUCTURE ICING  MODERATE:  .8%  SEVERE: NONE #OBS:   120
```

```
NOVEMBER                    D A T A    S U M M A R Y                        E844
          AVERAGE LATITUDE  26.0N               AVERAGE LONGITUDE  086.0W
--------------------------------------------------------------------------------
MEANS AND EXTREMES                     !        !                  ! NO. OF ! DAYS WITH
                        MIN   (DA HR) !   MEAN !   MAX   (DA HR) !  OBS   !   DATA
    AIR  TEMP (DEG C)  15.8   (30 21) !   21.3 !   27.0  (28 08) !   71   !    10
    SEA  TEMP (DEG C)  26.1   (26 15) !   26.7 !   27.3  (21 12) !   88   !    10
 AIR-SEA TEMP (DEG C) -11.0   (30 18) !  -06.1 !   00.2  (27 15) !   63   !    10
    PRESSURE  (MBAR) 1002.8   (26 21) ! 1017.2 ! 1028.3  (23 15) !   69   !    10
--------------------------------------------------------------------------------
WIND - % FREQUENCIES, MEANS AND EXTREMES
        !------- SPEED   (KNOTS)-------------!-------! MEAN
   -----!           4-    11-   22-   34-      ! TOTAL ! SPEED    NO. OF OBS:    81
   DIR  !   <4     10    21    33    47  >47   !   %   !(KNOTS)
   -----!                                      !       !
   N    !          1.2  25.9  12.3             !  39.5 ! 17.8        MAX WIND
   NE   !               12.3                   !  12.3 ! 15.6     SPEED:  26 KNOTS
   E    !                4.9                   !   4.9 ! 15.8     DIRECTION: 010 DEG
   SE   !          3.7   3.7                   !   7.4 ! 13.0     DAY:    30
   S    !          7.4  16.0                   !  23.5 ! 12.3     HOUR:   21
   SW   !                3.7                   !   3.7 ! 10.7
   W    !          1.2                         !   1.2 !  4.0
   NW   !          1.2   6.2                   !   7.4 ! 14.3
   CALM !                                      !       !
   TOTAL!         14.8  72.8  12.3             ! 100.0 ! 15.4
--------------------------------------------------------------------------------
```

```
NOVEMBER                    D A T A    S U M M A R Y                        E861
          AVERAGE LATITUDE  28.5N               AVERAGE LONGITUDE  080.0W
--------------------------------------------------------------------------------
MEANS AND EXTREMES                     !        !                  ! NO. OF ! DAYS WITH
                        MIN   (DA HR) !   MEAN !   MAX   (DA HR) !  OBS   !   DATA
    AIR  TEMP (DEG C)  03.4   (28 15) !   16.8 !   29.8  (27 18) !  234   !    30
--------------------------------------------------------------------------------
WIND - % FREQUENCIES, MEANS AND EXTREMES
        !------- SPEED   (KNOTS)-------------!-------! MEAN
   -----!           4-    11-   22-   34-      ! TOTAL ! SPEED    NO. OF OBS:   233
   DIR  !   <4     10    21    33    47  >47   !   %   !(KNOTS)
   -----!                                      !       !
   N    !    .9    5.2  10.3   3.9             !  20.2 ! 14.1        MAX WIND
   NE   !          3.9  20.2  12.9    .4       !  37.3 ! 18.3     SPEED:  38 KNOTS
   E    !    .4    8.3   6.0   2.1             !  16.7 ! 12.7     DIRECTION: 080 DEG
   SE   !          2.1   1.7   1.3             !   5.2 ! 15.2     DAY:    13
   S    !    .9    8.6   3.4                   !  12.9 !  9.6     HOUR:   15
   SW   !    .4    1.7   2.6                   !   4.7 ! 11.6
   W    !    .4     .4                         !    .9 !  4.0
   NW   !    .4    1.3    .4                   !   2.1 !  7.0
   CALM !                                      !       !
   TOTAL!   3.4   31.3  44.6  20.2    .4       ! 100.0 ! 14.6
--------------------------------------------------------------------------------
```

```
NOVEMBER                    D A T A    S U M M A R Y                        E870
          AVERAGE LATITUDE  56.5N               AVERAGE LONGITUDE  142.5W
--------------------------------------------------------------------------------
MEANS AND EXTREMES                     !        !                  ! NO. OF ! DAYS WITH
                        MIN   (DA HR) !   MEAN !   MAX   (DA HR) !  OBS   !   DATA
    AIR  TEMP (DEG C)  01.8   (28 18) !   06.2 !   10.6  (15 00) !  218   !    30
    SEA  TEMP (DEG C)  07.8   (22 06) !   09.5 !   08.8  (02 09) !  218   !    30
 AIR-SEA TEMP (DEG C) -07.2   (01 18) !  -03.5 !   01.7  (19 00) !  218   !    30
    PRESSURE  (MBAR) 0977.0   (19 09) ! 1007.1 ! 1031.2  (28 06) !  216   !    30
--------------------------------------------------------------------------------
WIND - % FREQUENCIES, MEANS AND EXTREMES
        !------- SPEED   (KNOTS)-------------!-------! MEAN
   -----!           4-    11-   22-   34-      ! TOTAL ! SPEED    NO. OF OBS:   216
   DIR  !   <4     10    21    33    47  >47   !   %   !(KNOTS)
   -----!                                      !       !
   N    !                                      !       !             MAX WIND
   NE   !           .5     .5                  !    .9 ! 14.0     SPEED:  43 KNOTS
   E    !    .9           8.8  22.3   7.4      !  39.5 ! 28.0     DIRECTION: 110 DEG
   SE   !          2.3  12.8  18.1             !  34.0 ! 21.8     DAY:    15
   S    !          1.4  12.1   4.7             !  18.1 ! 18.3     HOUR:   08
   SW   !           .8   1.8   1.4             !   4.2 ! 18.4
   W    !           .9   1.4                   !   2.3 ! 12.4
   NW   !    .5           .5                   !    .9 !  8.0
   CALM !                                      !       !
   TOTAL!   1.4    8.5  37.7  47.4   7.4       ! 100.0 ! 22.6
--------------------------------------------------------------------------------
WAVES - % FREQUENCIES, MEAN AND EXTREME  (METERS)           NO. OF WAVE  OBS:   184
HEIGHT  (M)  <1   1-1.5 2-2.5 3-3.5 4-5.5 6-7.5 8-9.5  >9.5 ! MEAN   MAX  (DA HR)
% FREQUENCY        1.1  22.3  33.7  38.7   3.3              ! 3.7M   7.5M (21 08)
--------------------------------------------------------------------------------
```

```
DECEMBER                    D A T A    S U M M A R Y                        E821
          AVERAGE LATITUDE  46.0N               AVERAGE LONGITUDE  131.0W
--------------------------------------------------------------------------------
MEANS AND EXTREMES                     !        !                  ! NO. OF ! DAYS WITH
                        MIN   (DA HR) !   MEAN !   MAX   (DA HR) !  OBS   !   DATA
    AIR  TEMP (DEG C)  08.1   (28 18) !   11.5 !   14.0  (15 18) !  247   !    31
    SEA  TEMP (DEG C)  11.5   (31 18) !   12.3 !   13.2  (06 08) !  247   !    31
 AIR-SEA TEMP (DEG C) -04.5   (08 06) !  -00.8 !   01.8  (15 18) !  247   !    31
    PRESSURE  (MBAR) 0980.4   (28 03) ! 1018.4 ! 1034.5  (02 18) !  247   !    31
--------------------------------------------------------------------------------
WIND - % FREQUENCIES, MEANS AND EXTREMES
        !------- SPEED   (KNOTS)-------------!-------! MEAN
   -----!           4-    11-   22-   34-      ! TOTAL ! SPEED    NO. OF OBS:   247
   DIR  !   <4     10    21    33    47  >47   !   %   !(KNOTS)
   -----!                                      !       !
   N    !    .8    1.6    .4                   !   2.8 !  6.7        MAX WIND
   NE   !   1.6           .8                   !   2.4 !  5.6     SPEED:  48 KNOTS
   E    !    .4    1.2   2.0                   !   3.6 ! 11.7     DIRECTION: 240 DEG
   SE   !    .4    2.0   1.6   5.3             !   9.3 ! 18.0     DAY:    28
   S    !    .4    3.2  13.0  13.8             !  30.4 ! 18.3     HOUR:   03
   SW   !    .8    1.8  11.7   3.2          .4 !  17.8 ! 17.5
   W    !          2.8  13.4   1.2    .4       !  17.8 ! 14.8
   NW   !   1.2    2.8   8.1   2.8    .4       !  15.4 ! 15.1
   CALM !    .4                                !    .4 !   .0
   TOTAL!   6.1   15.4  51.0  26.3    .8    .4 ! 100.0 ! 15.5
--------------------------------------------------------------------------------
WAVES - % FREQUENCIES, MEAN AND EXTREME  (METERS)           NO. OF WAVE  OBS:   247
HEIGHT  (M)  <1   1-1.5 2-2.5 3-3.5 4-5.5 6-7.5 8-9.5  >9.5 ! MEAN   MAX  (DA HR)
% FREQUENCY       20.2  32.0  33.6  13.8    .4              ! 2.7M   6.5M (28 06)
--------------------------------------------------------------------------------
```

```
DECEMBER                    D A T A    S U M M A R Y                        E834
          AVERAGE LATITUDE  40.1N               AVERAGE LONGITUDE  073.0W
--------------------------------------------------------------------------------
MEANS AND EXTREMES                     !        !                  ! NO. OF ! DAYS WITH
                        MIN   (DA HR) !   MEAN !   MAX   (DA HR) !  OBS   !   DATA
    AIR  TEMP (DEG C) -06.4   (03 12) !   02.7 !   12.6  (07 18) !   58   !     8
    SEA  TEMP (DEG C)  08.8   (02 00) !   08.0 !   08.3  (05 00) !   58   !     8
 AIR-SEA TEMP (DEG C) -15.4   (03 12) !  -06.3 !   03.5  (07 18) !   58   !     8
    PRESSURE  (MBAR) 0988.2   (07 18) ! 1024.6 ! 1034.6  (06 18) !   58   !     8
--------------------------------------------------------------------------------
WIND - % FREQUENCIES, MEANS AND EXTREMES
        !------- SPEED   (KNOTS)-------------!-------! MEAN
   -----!           4-    11-   22-   34-      ! TOTAL ! SPEED    NO. OF OBS:    59
   DIR  !   <4     10    21    33    47  >47   !   %   !(KNOTS)
   -----!                                      !       !
   N    !          8.5   3.4                   !  11.9 !  8.9        MAX WIND
   NE   !          3.4                         !   3.4 !  8.0     SPEED:  27 KNOTS
   E    !          1.7   6.8                   !   8.5 ! 14.2     DIRECTION: 300 DEG
   SE   !                5.1   1.7             !   6.8 ! 18.3     DAY:    03
   S    !   1.7    3.4   6.8   1.7             !  13.6 ! 12.8     HOUR:   06
   SW   !   1.7    3.4   5.1                   !  10.2 ! 11.3
   W    !   1.7    5.1   6.8   1.7             !  15.3 ! 12.3
   NW   !         13.6  11.9   5.1             !  30.5 ! 14.3
   CALM !                                      !       !
   TOTAL!   5.1   38.0  45.8  10.2             ! 100.0 ! 12.9
--------------------------------------------------------------------------------
% OF OBS WITH POTENTIAL SUPERSTRUCTURE ICING  MODERATE:13.8%  SEVERE: NONE #OBS:    58
```

```
DECEMBER                    D A T A    S U M M A R Y                        E841
          AVERAGE LATITUDE  38.7N               AVERAGE LONGITUDE  073.8W
--------------------------------------------------------------------------------
MEANS AND EXTREMES                     !        !                  ! NO. OF ! DAYS WITH
                        MIN   (DA HR) !   MEAN !   MAX   (DA HR) !  OBS   !   DATA
    AIR  TEMP (DEG C) -05.1   (30 12) !   04.8 !   14.4  (07 18) !  244   !    31
    SEA  TEMP (DEG C)  08.8   (28 03) !   09.8 !   10.5  (04 21) !  244   !    31
 AIR-SEA TEMP (DEG C) -14.8   (03 12) !  -05.3 !   04.1  (07 18) !  244   !    31
    PRESSURE  (MBAR) 0982.4   (21 08) ! 1016.1 ! 1038.4  (10 03) !  244   !    3'
--------------------------------------------------------------------------------
WIND - % FREQUENCIES, MEANS AND EXTREMES
        !------- SPEED   (KNOTS)-------------!-------! MEAN
   -----!           4-    11-   22-   34-      ! TOTAL ! SPEED    NO. OF OBS:   243
   DIR  !   <4     10    21    33    47  >47   !   %   !(KNOTS)
   -----!                                      !       !
   N    !          2.1  10.3   1.6             !  14.0 ! 14.6        MAX WIND
   NE   !    .4    1.6   2.8                   !   4.9 !  9.9     SPEED:  33 KNOTS
   E    !           .8   1.6                   !   2.5 ! 12.3     DIRECTION: 310 DEG
   SE   !           .4   1.6                   !   2.1 ! 13.8     DAY:    13
   S    !    .8    4.5   5.8    .4             !  11.5 ! 13.0     HOUR:   15
   SW   !    .4    3.7  12.8   2.1             !  18.9 ! 15.2
   W    !          1.6   7.8   6.2             !  15.6 ! 18.5
   NW   !   1.2    3.3  10.3  15.2             !  30.0 ! 20.2
   CALM !    .4                                !    .4 !   .0
   TOTAL!   3.3   18.1  53.1  25.5             ! 100.0 ! 16.6
--------------------------------------------------------------------------------
WAVES - % FREQUENCIES, MEAN AND EXTREME  (METERS)           NO. OF WAVE  OBS:   248
HEIGHT  (M)  <1   1-1.5 2-2.5 3-3.5 4-5.5 6-7.5 8-9.5  >9.5 ! MEAN   MAX  (DA HR)
% FREQUENCY  18.5  37.5  31.5  10.5   1.6    .4              ! 1.7M   7.0M (31 12)
--------------------------------------------------------------------------------
% OF OBS WITH POTENTIAL SUPERSTRUCTURE ICING  MODERATE: 7.4%  SEVERE: NONE #OBS:   243
```

```
DECEMBER                    D A T A    S U M M A R Y                        E844
          AVERAGE LATITUDE  26.0N               AVERAGE LONGITUDE  086.0W
--------------------------------------------------------------------------------
MEANS AND EXTREMES                     !        !                  ! NO. OF ! DAYS WITH
                        MIN   (DA HR) !   MEAN !   MAX   (DA HR) !  OBS   !   DATA
    AIR  TEMP (DEG C)  14.3   (22 00) !   20.8 !   25.4  (20 21) !  228   !    31
    SEA  TEMP (DEG C)  25.0   (27 08) !   25.8 !   26.7  (18 00) !  218   !    31
 AIR-SEA TEMP (DEG C) -11.4   (22 00) !  -05.2 !  -00.2  (12 15) !  208   !    31
    PRESSURE  (MBAR) 1005.5   (26 00) ! 1017.6 ! 1028.4  (08 15) !  218   !    31
--------------------------------------------------------------------------------
WIND - % FREQUENCIES, MEANS AND EXTREMES
        !------- SPEED   (KNOTS)-------------!-------! MEAN
   -----!           4-    11-   22-   34-      ! TOTAL ! SPEED    NO. OF OBS:   243
   DIR  !   <4     10    21    33    47  >47   !   %   !(KNOTS)
   -----!                                      !       !
   N    !               10.7   4.1             !  14.8 ! 18.8        MAX WIND
   NE   !          2.5  18.5   4.1             !  25.1 ! 16.8     SPEED:  27 KNOTS
   E    !    .4    4.8  18.0   3.1             !  23.5 ! 15.1     DIRECTION: 350 DEG
   SE   !    .4    5.3   6.6                   !  12.3 ! 11.7     DAY:    26
   S    !    .4    4.1   4.5                   !   9.5 ! 11.4     HOUR:   21
   SW   !           .8   7.4                   !   8.2 ! 15.1
   W    !                2.8                   !   2.8 ! 18.8
   NW   !           .8   2.1    .8             !   3.7 ! 18.4
   CALM !                                      !       !
   TOTAL!   1.2   18.5  68.1  11.1             ! 100.0 ! 15.4
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DECEMBER                    D A T A    S U M M A R Y                        E861
          AVERAGE LATITUDE  28.5N               AVERAGE LONGITUDE  080.0W
--------------------------------------------------------------------------------
MEANS AND EXTREMES                     !        !                  ! NO. OF ! DAYS WITH
                        MIN   (DA HR) !   MEAN !   MAX   (DA HR) !  OBS   !   DATA
    AIR  TEMP (DEG C)  04.8   (21 12) !   15.8 !   22.4  (13 03) !  236   !    31
--------------------------------------------------------------------------------
WIND - % FREQUENCIES, MEANS AND EXTREMES
        !------- SPEED   (KNOTS)-------------!-------! MEAN
   -----!           4-    11-   22-   34-      ! TOTAL ! SPEED    NO. OF OBS:   235
   DIR  !   <4     10    21    33    47  >47   !   %   !(KNOTS)
   -----!                                      !       !
   N    !          2.6   6.8   5.5    .4       !  15.3 ! 18.4        MAX WIND
   NE   !          6.4  10.2   7.7             !  24.3 ! 17.5     SPEED:  36 KNOTS
   E    !    .8    6.4  17.0   3.8             !  28.1 ! 13.6     DIRECTION: 010 DEG
   SE   !          4.7   7.2   1.3             !  13.2 ! 14.6     DAY:    26
   S    !          3.8   3.8    .8             !   8.5 ! 12.3     HOUR:   00
   SW   !           .8   3.0   1.3             !   5.1 ! 15.8
   W    !           .8   1.3                   !   2.1 ! 14.4
   NW   !    .8     .8    .8                   !   2.6 !  8.0
   CALM !    .8                                !    .8 !   .0
   TOTAL!   2.6   26.4  50.2  20.4    .4       ! 100.0 ! 15.2
--------------------------------------------------------------------------------
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DECEMBER                    D A T A    S U M M A R Y                        E870
          AVERAGE LATITUDE  56.5N               AVERAGE LONGITUDE  142.5W
--------------------------------------------------------------------------------
MEANS AND EXTREMES                     !        !                  ! NO. OF ! DAYS WITH
                        MIN   (DA HR) !   MEAN !   MAX   (DA HR) !  OBS   !   DATA
    AIR  TEMP (DEG C)  00.7   (08 18) !   04.6 !   07.4  (01 00) !  226   !    31
    SEA  TEMP (DEG C)  06.6   (28 21) !   07.3 !   08.1  (05 21) !  228   !    31
 AIR-SEA TEMP (DEG C) -06.8   (08 15) !  -02.7 !   00.3  (30 12) !  225   !    31
    PRESSURE  (MBAR) 0960.8   (15 12) ! 1004.2 ! 1028.3  (02 21) !  227   !    31
--------------------------------------------------------------------------------
WIND - % FREQUENCIES, MEANS AND EXTREMES
        !------- SPEED   (KNOTS)-------------!-------! MEAN
   -----!           4-    11-   22-   34-      ! TOTAL ! SPEED    NO. OF OBS:   227
   DIR  !   <4     10    21    33    47  >47   !   %   !(KNOTS)
   -----!                                      !       !
   N    !           .4                         !    .4 !  7.0        MAX WIND
   NE   !    .4     .4                         !    .9 !  4.5     SPEED:  38 KNOTS
   E    !           .8  13.2  18.5   5.3       !  37.8 ! 24.4     DIRECTION: 080 DEG
   SE   !          1.8   7.5   8.5    .8       !  18.4 ! 21.8     DAY:    18
   S    !    .4    4.0  10.1   3.1             !  17.6 ! 15.6     HOUR:   08
   SW   !          2.5   7.5   4.4             !  15.9 ! 17.6
   W    !    .4     .4   4.8    .8             !   6.6 ! 15.9
   NW   !    .4     .8                         !   1.3 !  5.3
   CALM !                                      !       !
   TOTAL!   1.8   12.3  43.6  38.1   6.2       ! 100.0 ! 20.2
--------------------------------------------------------------------------------
WAVES - % FREQUENCIES, MEAN AND EXTREME  (METERS)           NO. OF WAVE  OBS:   208
HEIGHT  (M)  <1   1-1.5 2-2.5 3-3.5 4-5.5 6-7.5 8-9.5  >9.5 ! MEAN   MAX  (DA HR)
% FREQUENCY        8.3  35.8  22.8  25.7   7.3              ! 3.3M   7.5M (19 12)
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(Continued on page 201.)

Table 19
Selected Gale and Wave Observations, North Atlantic
November and December 1976

Vessel	Nationality	Date	Position of Ship Lat. deg.	Long. deg.	Time GMT	Wind Dir. 10°	Wind Speed kt.	Visibility n. mi.	Present Weather code	Pressure mb.	Temperature °C Air	Temperature °C Sea	Sea Waves* Period sec.	Sea Waves* Height ft.	Swell Waves Dir. 10°	Swell Waves Period sec.	Swell Waves Height ft.
NORTH ATLANTIC OCEAN		NOV.															
DOCTOR LYKES	AMERICAN	2	46.3 N	13.0 W	12	27	30	10 NM	16	1015.0	13.9	13.4	5	19.5	29	12	24.9
HOLY QUEEN	SINGAPORE	3	47.3 N	09.5 W	06	30	M 30	2 NM	64	1003.5	19.0	19.0	10	13	30	8	23
ROBERT STOVE	NORWEGIAN	5	47.0 N	23.0 W	18	27	45	10 NM	80	1005.0	11.0	13.5			27	12	32.5
SEALAND PRODUCER	AMERICAN	5	39.3 N	54.7 W	12	12	42	10 NM	01	1010.0	22.3	18.3	4	8			
SEALAND CONSUMER	AMERICAN	6	39.2 N	57.5 W	18	27	38	10 NM	02	1006.8	20.6	22.8	4	10	27	10	41
RED JACKET	AMERICAN	6	40.3 N	60.0 W	18	27	45	10 NM	01	1005.7	15.6	21.7	3	10	27	12	10
ROBERT STOVE	NORWEGIAN	6	48.9 N	23.4 W	00	29	45	5 NM	80	1010.0	12.0	13.5					
ADM W M CALLAGHAN	AMERICAN	6	40.4 N	66.9 W	18	28	45	10 NM	01	1011.9	10.0	12.8	6	10			
SEALAND CONSUMER	AMERICAN	7	39.7 N	54.7 W	00	27	38	10 NM	02	1010.8	18.8	21.7	4	13	27	10	49
AMER CHAMPION	AMERICAN	8	33.4 N	71.1 W	18	32	50	5 NM	25	1009.0	19.4	24.0	7	13	30	10	18
SHERMAN	AMERICAN	8	38.3 N	71.7 W	18	32	M 48	1 NM	65	1001.5	7.8	17.3	8	13			
LASH PACIFICO	AMERICAN	9	39.5 N	62.1 W	00	14	49	5 NM	95	987.0	18.4	23.9	10	19.5			
SEALAND CONSUMER	AMERICAN	9	39.9 N	44.3 W	18	20	30	10 NM	03	1010.0	22.3	22.3	4	10	20	7	32.5
AMER CHAMPION	AMERICAN	9	33.2 N	72.5 W	00	32	49	10 NM	02	1014.3	13.9	22.8	9	16.5			
AMER LEGACY	AMERICAN	9	47.0 N	24.6 W	06	33	35	10 NM	15	1011.0	10.0	13.5	5	10	29	7	16.5
SEALAND RESOURCE	AMERICAN	10	39.5 N	57.6 W	06	27	42	5 NM	02	1011.0	19.3	21.1	5	13			
SEALAND CONSUMER	AMERICAN	10	40.0 N	44.0 W	00	20	30	5 NM	02	1008.0	22.1	22.3	4	10	20	7	32.5
AMER LEGACY	AMERICAN	12	42.7 N	58.3 W	18	28	47	> 25 NM	02	1011.0	7.8	11.2	3	10	27	6	14.5
LIGHTNING	AMERICAN	12	46.0 N	49.2 W	18	27	48	5 NM	26	1000.7	4.4	7.0	2	8.5	27	6	14.5
LIGHTNING	AMERICAN	13	45.7 N	30.7 W	00	27	45	5 NM	01	1006.4	5.0	7.8	3	8	27	8	18
CHASE	AMERICAN	17	38.2 N	50.0 W	00	19	M 49	.5 NM	97	992.0	23.0	21.1	6	11.5	24	6	10
SEALAND MARKET	AMERICAN	17	34.3 N	47.8 W	06	25	30	10 NM	07	1000.0	21.1	20.0	7	32.5			
SAN BLAS	SWEDISH	18	40.3 N	31.9 W	00	15	40	5 NM	80	1002.7	20.0		6	32.5			
SEALAND MARKET	AMERICAN	18	34.0 N	57.6 W	00	33	48	10 NM	25	1015.9	17.8	19.4	6	11.5	29	>13	24.9
CHASE	AMERICAN	19	43.1 N	50.3 W	12	11	M 45	1 NM	07	989.0	12.2	13.3	4	14.5	30	< 6	10
AMOCO BRISBANE	LIBERIAN	19	36.8 N	63.1 W	12	29	42	5 NM	29	1000.3	13.0	20.0	8	13			
AMER ARGOSY	AMERICAN	19	37.5 N	60.7 W	18	29	48	5 NM	03	1000.0	15.8	22.3			29	9	19.5
ROBERT STOVE	NORWEGIAN	19	47.3 N	30.6 W	18	10	45	5 NM	02	991.0	7.0	5.0	4	8	13	10	28
LIGHTNING	AMERICAN	19	40.1 N	52.3 W	18	28	35	5 NM	16	985.1	14.0	20.0			28	8	26
GREEN WAVE	AMERICAN	19	33.1 N	58.9 W	12	27	50	5 NM	02	1002.7	21.1	22.2	6	11.5	27	7	41
EXPORT LEADER	AMERICAN	19	39.0 N	50.8 W	18	27	50	10 NM	02	989.2	15.5	21.1	7	19.5	20	8	14.8
EXPORT BAY	AMERICAN	19	38.1 N	39.5 W	12	29	50	2 NM	64	992.0	12.2	22.7	7	14.5	28	9	39
CASUARINA	DANISH	19	45.3 N	48.6 W	18	10	M 44	5 NM	03	993.0	7.9	4.0	3	14.5	28	8	19.5
AMER ARGOSY	AMERICAN	20	37.7 N	58.7 W	00	20	45	5 NM	02	1000.0	17.8	22.3	4	5	29	10	13
AMOCO BRISBANE	LIBERIAN	20	37.0 N	63.3 W	00	29	41	5 NM	29	998.6	18.0	20.0	8	13			
ROBERT STOVE	NORWEGIAN	20	47.4 N	30.4 W	00	11	35	2 NM	62	985.0	6.5	6.0	4	13	13	11	32.8
LIGHTNING	AMERICAN	20	39.9 N	50.1 W	00	24	45	5 NM	29	990.7	14.4	21.1	9	6.5	26	8	24.5
EXPORT LEADER	AMERICAN	20	39.5 N	32.6 W	00	27	50	10 NM	01	994.6	14.0	21.6	7	19.5			
AMER LEGEND	AMERICAN	22	41.5 N	62.3 W	12	28	M 42	5 NM	27	1004.1	8.3	16.7	5	10	28	11	11.9
STAGHOUND	AMERICAN	23	49.7 N	32.7 W	18	20	45	1 NM	81	1007.1	12.8	11.6	8	19.5	20	12	24.5
STAGHOUND	AMERICAN	24	49.5 N	32.9 W	00	20	45	1 NM	80	1006.1	13.4	11.6	8	19.5	20	12	26
AMER ACCORD	AMERICAN	27	46.0 N	41.1 W	06	29	45	10 NM	01	1012.9	6.2	14.4	8	10	29	8	19.5
AMER LEGACY	AMERICAN	27	46.7 N	36.2 W	00	26	50	5 NM	02	1000.5	10.0	19.4	8	16.5			
CHERRY VALLEY	AMERICAN	30	49.3 N	03.6 W	12	24	45	.5 NM	81	988.5	12.8	11.7	5	14.5			
OCEAN STATION VESSELS																	
ATLANTIC H																	
TANEY	AMERICAN	8	38.0 N	70.8 W	21	32	M 44	5 NM	01	1007.0	9.4	18.4	8	18			
TANEY	AMERICAN	9	37.9 N	70.9 W	00	31	M 49	5 NM	07	1009.2	8.4	19.0	9	21			
BIBB	AMERICAN	19	38.0 N	71.0 W	00	32	M 43	5 NM	02	1007.3	13.1	20.4	6	14.5			
GREAT LAKES VESSELS																	
G M HUMPHREY	AMERICAN	8	47.2 N	85.8 W	00	33	M 44	10 NM	70		- 7.0	0.0	6	10			
WILLIAM A IRVIN	AMERICAN	14	47.6 N	87.6 W	00	27	M 49	10 NM	02		4.0	7.0	15	14.5			
WILLIAM A REISS	AMERICAN	14	47.5 N	88.4 W	00	25	M 42	5 NM	02		4.0	4.0	12	14.5			
WILLIAM A REISS	AMERICAN	18	47.2 N	86.6 W	06	33	M 42	10 NM	03		4.0	4.0	4	8			
JOHN SHERWIN	AMERICAN	22	47.1 N	86.7 W	18	33	M 41	10 NM	02		0.0	3.0	6	10			
G M HUMPHREY	AMERICAN	23	47.8 N	87.6 W	00	31	M 42	10 NM	70		- 5.0	0.0	9	10			
G M HUMPHREY	AMERICAN	30	42.4 N	80.5 W	00	26	M 46	2 NM	85		- 9.0	7.0	6	8			
NORTH ATLANTIC OCEAN		DEC.															
PIONEER COMMANDER	AMERICAN	1	48.9 N	04.4 W	18	26	60	2 NM	60	975.5	8.9	12.3	6	14.5			
SEALAND PRODUCER	AMERICAN	1	46.1 N	11.4 W	18	27	38	2 NM	29	987.0	14.0	11.2			27	6	14.5
SEALAND PRODUCER	AMERICAN	2	45.2 N	12.1 W	00	31	35	2 NM	29	1001.0	17.7	10.0	5	13	28	6	13
AMER RANGER	AMERICAN	3	46.0 N	11.5 W	00	27	47	5 NM	01	998.0	10.5	12.0	5	8	27	6	19.5
PERNGROVE	NORWEGIAN	4	44.4 N	34.5 W	18	27	45	5 NM	02	1015.6	4.4	4.0	8	16.5	27	10	29.5
AMER RANGER	AMERICAN	4	43.8 N	19.6 W	00	27	45	5 NM	01	1016.5	11.5	11.0	9	16.5	27	9	24.5
EXPORT PATRIOT	AMERICAN	5	51.1 N	18.2 W	18	25	50	10 NM	25	971.2	6.7	14.4	5	14.5	25	10	24.5
SEALAND GALLOWAY	AMERICAN	5	47.7 N	13.0 W	12	19	41	2 NM	03	989.0	10.6	11.7	6	11.5	25	6	8
EXPORT PATRIOT	AMERICAN	6	51.1 N	20.0 W	00	27	50	5 NM	29	965.0	6.4	11.2	6	13	27	10	29.5
AMER ARGOSY	AMERICAN	6	43.6 N	38.3 W	18	27	30	10 NM	27	999.5	8.8	14.9	3	10	27	8	46
FACSTRIA	DANISH	7	33.3 N	45.5 W	06	06	M 49	10 NM	60	1014.0	20.8		8	14.8			
SAN JUAN	AMERICAN	7	34.8 N	74.0 W	18	18	49	2 NM	25	1004.7	21.1	20.0	6	14.5	13	6	14.5
AMER ARGOSY	AMERICAN	7	43.5 N	27.5 W	06	31	30	10 NM	03	1005.0	10.0	14.5	3	10	29	8	41
MOBIL AERO	AMERICAN	8	41.2 N	69.2 W	00	20	28	1 NM	80	997.0	12.3	9.0	3	5	14	>13	32.5
EAGLE CHARGER	AMERICAN	8	39.4 N	54.7 W	18	17	45	5 NM	07	1017.3	20.0	17.4			17	9	14.5
EXPORT PATRIOT	AMERICAN	8	49.6 N	37.5 W	00	33	49	10 NM	02	1016.5	4.0	8.8	6	8	33	8	23
AMER ARGOSY	AMERICAN	8	42.2 N	33.5 W	06	33	30	10 NM	60	1013.0	10.0	15.6	3	8	34	8	24.5
MOBIL AERO	AMERICAN	9	35.7 N	72.5 W	06	24	48	5 NM	02	1021.0	5.6	20.0	5	10			
EXPORT PATRIOT	AMERICAN	9	48.0 N	47.6 W	00	21	30	5 NM	60	1001.5	5.0	4.6	5	10	21	8	19.9
BOREANNA	BRAZILIAN	9	36.3 N	74.7 W	00	32	M 48	80 VD	82	1014.0		15.0					
RESEARCHER	AMERICAN	9	42.9 N	69.8 W	18	30	M 41	10 NM	07	1024.0	- 4.0	7.1	3	8	28	< 6	13
SEALAND MARKET	AMERICAN	9	38.1 N	58.3 W	12	25	38	5 NM	21	998.0	17.7	17.4			25	6	13
RED JACKET	AMERICAN	9	41.2 N	62.2 W	18	30	38	10 NM	66	1012.5	2.2	14.4			29	>13	13
EAGLE CHARGER	AMERICAN	9	39.2 N	50.3 W	18	20	45	5 NM	05	1008.8	22.0	20.0	9	13	20	9	10
RED JACKET	AMERICAN	10	41.3 N	62.9 W	06	31	35	10 NM	02	1031.0	0.0	15.6			29	>13	13
SEALAND MARKET	AMERICAN	10	38.6 N	60.9 W	00	30	33	5 NM	90	1021.7	8.3	18.8	9	14.5	29	>13	39
AMER ARGOSY	AMERICAN	10	40.4 N	49.9 W	18	30	45	5 NM	68	1028.0	0.7	20.9	2	5	30	8	13

Vessel	Nationality	Date	Position of Ship		Time GMT	Wind			Visibility n. mi.	Present Weather code	Pressure mb.	Temperature °C.		Sea Waves†		Swell Waves		
			Lat. deg.	Long. deg.		Dir. 10°		Speed kt.				Air	Sea	Period sec.	Height ft.	Dir. 10°	Period sec.	Height ft.
NORTH ATLANTIC OCEAN		DEC.																
BALAO	NORWEGIAN	10	24.3 N	69.4 W	18	06		45	5	NM 60	1030.0	23.0	25.0	6	10			
EXPORT PATRIOT	AMERICAN	10	45.8 N	36.2 W	00	29		35	200	YD 86	993.0	- 9.0	3.3	6	11.5	28	10	32.5
EAGLE CHARGER	AMERICAN	10	40.6 N	44.1 W	18	29		30	5	NM 79	1022.0	8.0	17.7	8	13	29	9	16.5
HADJI AGUS SALIM	INDONESIAN	10	37.4 N	55.3 W	12	32		45	10	NM 03	1032.5	11.5	20.0	13	24.5			
SOLON TURMAN	AMERICAN	11	29.3 N	26.3 W	00	31		30	10	NM 03	1012.5	18.9	21.1			32	10	16.5
AMER LEGACY	AMERICAN	12	47.5 N	37.5 W	12	26		30	5	NM 25	1017.0	9.4	13.9			26	>13	23
DOCTOR LYKES	AMERICAN	12	42.6 N	22.0 W	06	36		35	5	NM 07	1016.5	10.8	13.4			32	12	18
RESEARCHER	AMERICAN	13	40.7 N	72.1 W	15	30	M	30	5	NM 02	1014.0		7.2			29	6	13
SEALAND GALLOWAY	AMERICAN	13	35.5 N	18.0 W	12	34		49	5	NM 18	1011.3	15.6	16.7	4	10	32	11	16.5
CHASE	AMERICAN	13	41.5 N	69.4 W	18	29	M	45	5	NM 07	1007.5	- 3.9	0.1	4	11.5			
SHERMAN	AMERICAN	13	39.5 N	73.4 W	18	31	M	46	5	NM 02	1019.2	0.2	8.8	4	13			
J LOUIS	LIBERIAN	13	39.9 N	67.3 W	18	30		42	2	NM 10	1005.0	6.5	10.0	6	10			
EXPORT DEMOCRACY	AMERICAN	13	37.0 N	36.7 W	18	23		30	5	NM 80	1001.7	21.7	21.1			23	6	18
LIGHTNING	AMERICAN	13	41.9 N	52.3 W	18	22		45	5	NM 60	998.8	16.8	12.5	3	10	22	7	24.5
CHASE	AMERICAN	14	41.0 N	69.2 W	00	32	M	51	2	NM 07	1020.0	- 4.4	0.7	6	14.5			
ADM W M CALLAGHAN	AMERICAN	14	38.3 N	46.5 W	18	31		41	5	NM 18	1014.3	15.6	19.1	5	10	28	10	16.5
J LOUIS	LIBERIAN	14	40.7 N	62.5 W	12	31		30	2	NM 71	1023.0	2.0	13.0	6	10	31	8	16.5
EXPORT FREEDOM	AMERICAN	14	39.3 N	48.8 W	12	27		45	5	NM 02	1005.8	13.0	13.5	5	11.5	26	8	29.5
SEALAND GALLOWAY	AMERICAN	16	40.0 N	62.4 W	18	02		45	2	NM 21	991.5	21.1	13.6	3	8	18	6	10
ESSO ANTWERP	BELGIAN	16	35.8 N	72.6 W	18	23	M	30	2	NM 16	998.5	21.1	23.3			23	12	13
STAGHOUND	AMERICAN	18	41.3 N	53.7 W	12	27		45	10	NM 18	993.0	11.7	18.3	4	8	26	8	14.5
MOBIL GAS	AMERICAN	18	39.5 N	69.3 W	18	31		45	10	NM 02	1011.2	10.0	17.8	7	13	31	9	19.5
STAGHOUND	AMERICAN	19	41.0 N	57.8 W	18	30		45	5	NM 93	1001.0	7.2	16.3	5	10	24	8	14.5
JOHN A MCCONE	AMERICAN	19	32.3 N	10.4 W	12	22	M	42	2	NM 81	1012.0	16.5	20.6	4	16.5			
STAGHOUND	AMERICAN	20	40.5 N	39.0 W	00	30		45	5	NM 01	1010.5	9.0	21.7	5	10	27	8	19.5
TEXACO MISSISSIPPI	AMERICAN	21	36.1 N	75.1 W	18	29		42	10	NM 01	1007.8		10.6	6	8			
DEFIANCE	AMERICAN	21	38.7 N	61.6 W	18	20		45	5	NM 02	990.8	19.4	18.9	7	10	18	7	19.5
DONA CORAZON II	PHILIPPINE	21	31.2 N	70.5 W	12	21	M	33	2	NM 02	1002.1	22.0	21.0		18			
LASH PACIFICO	AMERICAN	21	38.0 N	60.0 W	22	17		45	200	YD 07	998.2	18.4	20.0	8	19.5	24	12	16.5
OGDEN WILLAMETTE	AMERICAN	21	29.7 N	80.3 W	18	30		45	10	NM 02	1018.5	16.2	24.0	6	13			
ADM W M CALLAGHAN	AMERICAN	21	40.4 N	58.8 W	18	18		41	2	NM 07	989.2	20.5	16.0	10	13	20	10	16.5
LASH PACIFICO	AMERICAN	22	37.5 N	61.0 W	12	27		45	10	NM 16	1005.8	13.0	20.0	18	32.5	32	>13	24.5
ELIZABETHPORT	AMERICAN	22	40.1 N	58.5 W	18	29		45	10	NM 01	1007.1	10.0	17.2	6	10	28	6	14.5
ADM W M CALLAGHAN	AMERICAN	22	40.5 N	49.5 W	18	18		30	2	NM 30	1001.8	20.6	14.5	10	18			
SEALAND PRODUCER	AMERICAN	22	35.4 N	57.1 W	06	18	M	45	5	NM 02	1005.8	22.0	17.7	4	6.5	18	9	9
AMER ACCORD	AMERICAN	24	43.5 N	57.8 W	12	15		42	2	NM 81	1000.3	11.1	14.4	10	19.5			
PRES POLK	AMERICAN	24	39.8 N	57.6 W	18	28		45	2	NM 97	1002.0	11.7	19.4	10	19.5	22	12	16.5
OVERSEAS ARCTIC	AMERICAN	25	35.3 N	49.0 W	18	31		36	2	NM 58	999.3	15.5	18.3	5	10	30	8	59
AUSTRAL PILGRIM	AMERICAN	26	29.3 N	44.0 W	06	28		45	5	NM 18	1007.9	20.0	22.0	7	6.5			
AMER ALLIANCE	AMERICAN	26	43.4 N	51.4 W	06	32		47	2	NM 60	1006.1	3.2	7.7	7	11.5	31	9	14.5
OVERSEAS ARCTIC	AMERICAN	26	35.0 N	50.5 W	00	34		30	2	NM 16	1010.5	13.6	18.9	5	18	34	9	41
MOBIL GAS	AMERICAN	26	26.3 N	87.7 W	18	33		45	10	NM 02	1015.9	17.3	26.3	4	8	33	9	16.5
BALTIMORE TRADER	AMERICAN	27	31.8 N	75.8 W	12	31		45	5	NM 02	1000.7	9.4	21.7	8	10	31	8	32.5
ESSO ANTWERP	BELGIAN	27	33.3 N	71.7 W	12	29	M	41	2	NM 64	999.8	12.9	19.4	6	14.5	30	< 6	18
GULFQUEEN	AMERICAN	27	32.6 N	70.1 W	18	30		45	5	NM 02	1003.0	11.7	20.0	XX	10	27	12	19.5
EXPORT COMMERCE	AMERICAN	27	40.4 N	56.7 W	18	13		35	1	NM 18	975.3	17.7	14.4			13	7	29.5
OVERSEAS ARCTIC	AMERICAN	27	33.1 N	57.4 W	18	20		64	.5	NM 81	999.0	18.5	18.9	12	19.5			
PIONEER COMMANDER	AMERICAN	27	34.2 N	68.0 W	18	90		80	5	NM 15	992.5	12.2	20.6	7	14.5	XX	X	24.5
AUSTRAL PILGRIM	AMERICAN	27	33.3 N	53.4 W	18	19		47	5	NM 21	997.5	21.0	21.5	8	23			
LASH ATLANTICO	AMERICAN	28	30.2 N	60.5 W	00	27		42	10	NM 01	995.6	19.5	20.0	8	10	25	10	19.5
PIONEER COMMANDER	AMERICAN	28	33.4 N	68.9 W	00	30		45	5	NM 16	1005.0	11.5	20.5	8	21	26	10	24.5
OVERSEAS ARCTIC	AMERICAN	28	32.8 N	57.4 W	00	27		70	5	NM 03	994.5	18.3	18.9			20	8	32.5
AUSTRAL PILGRIM	AMERICAN	28	33.0 N	53.5 W	06	27		52	5	NM 21	999.8	17.0	21.0	8	24.5			
SEALAND ECONOMY	AMERICAN	28	36.6 N	50.7 W	12	31		47	2	NM 02	994.1	13.4	20.5	5	8	22	6	10
AUSTRAL PILGRIM	AMERICAN	29	34.5 N	62.5 W	18	21		50	5	NM 18	1003.5	21.0	19.0	7	24.5			
VALLEY FORGE	AMERICAN	30	33.5 N	73.4 W	00	27		60	10	NM 01	1004.5	12.8	22.7	8	26			
HORGH OPAL	NORWEGIAN	30	43.0 N	55.5 W	06	22		48	10	NM 00	991.5	15.0	8.0	5	16.5	27	7	16.5
AUSTRAC PILGRIM	AMERICAN	30	36.7 N	66.7 W	18	27		60	5	NM 18	1008.7	14.0	19.0	8	21	27	8	32.5
ATLANTICA LIVORNO	GERMAN	30	42.8 N	59.7 W	18	27		52	5	NM 70	990.5	3.2	7.0			27	11	13
OGDEN WILLAMETTE	AMERICAN	31	31.7 N	73.5 W	18	19		50	1	NM 64	1004.2	20.0	18.7	6	13	19	6	16.5
AUSTRAL PILGRIM	AMERICAN	31	37.0 N	67.0 W	00	27		50	5	NM 02	1012.0	16.5	19.0	8	21	27	8	24.5
ATLANTICA LIVORNO	GERMAN	31	42.8 N	60.8 W	06	27		52	2	NM 62	994.5	1.0				27	10	16.5
OCEAN STATION VESSELS																		
ATLANTIC H																		
INGHAM	AMERICAN	7	38.0 N	71.0 W	18	17	M	53	5	NM 80	1008.8	20.2	23.1	8	18			
INGHAM	AMERICAN	8	38.0 N	71.0 W	00	23	M	47	2	NM 81	1001.0	19.1	18.0	9	23			
TANEY	AMERICAN	21	38.0 N	71.0 W	18	29	M	45	5	NM 16	996.7	3.7	15.5	5	14.5			
TANEY	AMERICAN	22	38.0 N	71.0 W	00	32	M	45	1	NM 86	1004.5	0.3	16.3	5	16.5			
INGHAM	AMERICAN	29	38.0 N	71.0 W	18	35	M	42	2	NM 81	992.1	6.6	14.2	7	8			
INGHAM	AMERICAN	31	38.0 N	71.0 W	09	27	M	53	5	NM 07	1003.5	12.8	16.0	9	18			
GREAT LAKES VESSELS																		
G M HUMPHREY	AMERICAN	2	47.3 N	85.2 W	06	02	M	46	200	YD 75		-19.0	7.0					
G M HUMPHREY	AMERICAN	14	47.3 N	89.3 W	06	20	M	42	10	NM 02		- 7.0	8.0	6	8			
LEON FRASER	AMERICAN	14	47.2 N	90.3 W	12	22	M	42	10	NM 01		- 4.0	8.0	5	10			
CASON J CALLAWAY	AMERICAN	14	47.0 N	91.3 W	12	25	M	43	10	NM 02		- 1.0	7.0	8	10			
ARTHUR M ANDERSON	AMERICAN	14	44.5 N	86.5 W	12	22	M	42	> 25	NM 01		0.0	5.0	9	11.5			
ENDERS M VOORHEES	AMERICAN	20	45.2 N	86.6 W	18	34	M	42	5	NM 02		- 7.0	4.0	7	8			
ARTHUR M ANDERSON	AMERICAN	20	44.9 N	86.4 W	12	33	M	41	2	NM 79		- 6.0	8.0					
BENJAMIN F FAIRLESS	AMERICAN	21	43.6 N	87.6 W	12	31	M	41	10	NM 01		-15.0	3.0	6	5			

† Direction for sea waves same as wind direction
X Direction or period of waves indeterminate
M Measured wind

NOTE: The observations are selected from those with winds ≥ 35 kn or waves ≥ 25 ft from May through August (≥ 41 kn or ≥ 33 ft, September through April). In cases where a ship reported more than one observation a day with such values, the one with the highest wind speed was selected.

Table 20
Selected Gale and Wave Observations, North Pacific
November and December 1976

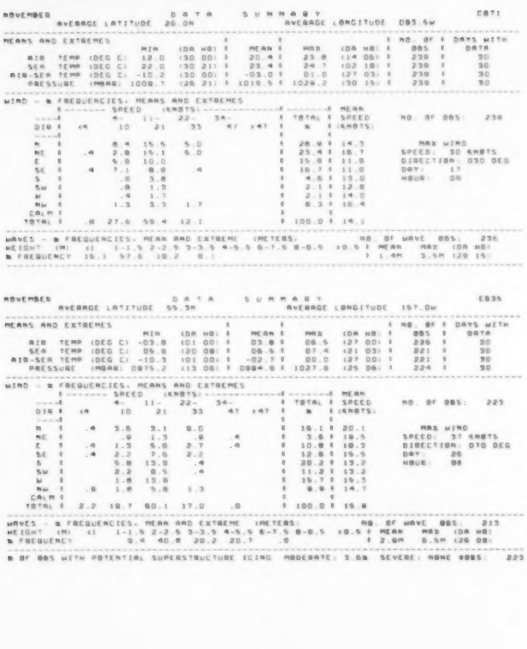
Vessel	Nationality	Date	Position of Ship Lat. deg.	Position of Ship Long deg.	Time GMT	Wind Dir. 10°	Wind Speed kt.	Visibility n. mi.	Present Weather code	Pressure mb	Temperature °C Air	Temperature °C Sea	Sea Waves* Period sec.	Sea Waves* Height ft.	Swell Waves Dir. 10°	Swell Waves Period sec.	Swell Waves Height ft.
NORTH PACIFIC OCEAN		NOV.															
SANTA MARIA	AMERICAN	1	52.2 N	135.3 W	00	25	46	10 NM	13	1003.4	6.7	11.1	5	13	24	8	16.5
SEALAND MC LEAN	AMERICAN	2	45.2 N	163.4 W	00	36	41	10 NM	02	1007.5	10.0	7.2	10	10	36	12	13
PACIFIC WING	PANAMANIAN	3	43.3 N	169.5 W	06	18	M 44	.5 NM	07	997.5	10.0	10.0	5	10			
LEO	LIBERIAN	3	47.4 N	160.8 E	06	31	M 46	10 NM	09	1002.0	6.2	7.0	5	10	31	7	16.5
OCTA	LIBERIAN	3	50.9 N	179.9 W	00	27	M 50	200 YD	80	972.2	6.0	6.0	14	19.5			
AXEL JOHNSON	SWEDISH	3	15.1 N	94.7 W	12	33	44	> 25 NM	07	1012.0	22.5	25.3					
TAIKO VENTURE	LIBERIAN	4	49.8 N	169.0 E	00	27	M 34	2 NM	26	993.6	3.3	6.0	10	19.5	27	>13	26
LONG BEACH	AMERICAN	4	13.7 N	94.7 W	00	36	45	10 NM	02	1011.2	25.6	26.7	6	19.5	01	7	23
OCTA	LIBERIAN	4	50.0 N	171.4 E	06	27	M 45	1 NM	50	993.2	5.0	8.0	14	24.5			
PRES TRUMAN	AMERICAN	5	37.0 N	150.4 E	12	05	45	5 NM	50	1015.9	14.0	19.0	5	5			
OCTA	LIBERIAN	5	47.4 N	162.4 E	18	27	M 45	1 NM	09	1005.6	4.0	6.0	12	24.5			
PRES KENNEDY	AMERICAN	6	53.0 N	179.4 W	12	25	48	5 NM	80	989.5	3.9	4.4	8	18			
OCTA	LIBERIAN	6	46.6 N	162.0 E	00	27	M 45	2 NM	09	1010.8	4.0	6.0	12	24.5			
PLUVIUS	GERMAN	7	43.1 N	157.2 W	18	19	44	10 NM	02	1000.2	11.5	10.2	5	6.5	20	7	10
SHUNWIND	LIBERIAN	7	55.0 N	179.1 W	00	26	M 44	10 NM	89	977.2	3.5	7.0	6	23	27	7	29.5
PLUVIUS	GERMAN	8	45.0 N	155.1 W	00	20	44	2 NM	80	1001.6	11.6	10.1	7	10			
PRES POLK	AMERICAN	8	51.1 N	149.5 E	06	23	45	5 NM	81	1008.5	23.3	22.8	8	19.5	26	10	28
PEARL VENTURE	LIBERIAN	8	47.8 N	169.0 E	06	29	48	2 NM	02	1005.0	4.0	5.0	6	11.5	28	8	26
SEALAND COMMERCE	AMERICAN	9	45.5 N	178.3 E	12	14	45	5 NM	02	981.5	8.3	6.1					
PRES KENNEDY	AMERICAN	9	47.2 N	159.0 E	03	32	90	.5 NM	28	983.0	2.2	4.4	8	19.5	32	8	24.5
PEARL VENTURE	LIBERIAN	9	46.5 N	164.1 E	06	25	42	1 NM	09	976.0	9.0	5.5	5	10	23	7	14.5
AMER MAIL	AMERICAN	9	43.4 N	174.7 W	18	17	48	2 NM	07	982.0	11.2	8.8	4	11.5	15	7	16
ATLANTIC PIONEER	PANAMANIAN	9	48.7 N	172.3 E	18	09	M 50	1 NM	58	967.0	4.0	5.0	10	29.5	09	12	32.5
KOREA PHOENIX	SINGAPORE	9	48.5 N	148.2 W	06	14	M 42	1 NM	89	997.5	9.0	8.0	6	11.5	16	9	19.5
GOLDEN MARINER	PANAMANIAN	9	50.3 N	178.0 E	15	10	M 41	5 NM	80	982.5	7.0	6.0	6	8	10	8	14.5
OCTA	LIBERIAN	9	41.9 N	143.2 E	00	32	M 45	1 NM	09	1021.2	6.0	8.0	12	11.5			
VAN FORT	LIBERIAN	9	44.3 N	166.7 E	12	26	M 90	1 NM	80	987.0	4.0	8.0					
UNION GREEN	LIBERIAN	9	47.1 N	178.4 E	18	11	M 70	.25 NM	82	951.0	6.0	8.0					
PRES KENNEDY	AMERICAN	10	47.1 N	156.3 E	06	31	60	10 NM	09	1015.0	0.6	3.3			31	8	21
PEARL VENTURE	LIBERIAN	10	43.9 N	162.9 E	06	31	44	1 NM	02	1007.0	4.0	5.0	5	11.5	32	8	32.5
PRES TRUMAN	AMERICAN	10	49.1 N	157.2 W	18	18	60	5 NM	80	984.5	6.6	7.1			18	9	32.5
ATLANTIC PIONEER	PANAMANIAN	10	48.5 N	173.3 E	00	02	M 50	1 NM	58	963.5	4.0	5.0	10	29.5	02	>13	32.5
GOLDEN MARINER	PANAMANIAN	10	50.9 N	178.8 E	09	08	M 80	2 NM	80	966.6	4.0	5.5	6	11.5	04	9	23
VAN FORT	LIBERIAN	10	44.5 N	166.4 E	00	30	M 45	2 NM	70	988.0	4.0	8.0					
UNION GREEN	LIBERIAN	10	46.1 N	177.8 E	06	25	M 60	.25 NM	82	944.0	10.0	7.0					
THOMAS E CUFFE	AMERICAN	11	37.1 N	163.6 W	18	29	42	5 NM	07	1004.4	12.8	17.2	XX	10	27	9	32.5
TOYOTA MARU #12	JAPANESE	11	33.8 N	167.9 W	18	29	M 41	10 NM	01	1016.0	16.0	18.5	7	10	29	9	28
YAMASHIN MARU	JAPANESE	11	39.8 N	168.1 W	00	25	M 80	5 NM	02	980.0	14.0	14.0			25	< 6	14.5
PRES TRUMAN	AMERICAN	11	49.5 N	151.5 W	06	18	65	2 NM	80	1000.0	8.0	8.0			18	9	39
LONG BEACH	PANAMANIAN	12	35.2 N	161.0 W	00	31	M 45	5 NM	03	1011.2	17.0	19.5	10	21			
THOMAS E CUFFE	AMERICAN	12	37.2 N	164.2 W	00	28	40	5 NM	07	1009.0	13.3	17.2	XX	10	28	12	32.5
TOYOTA MARU #12	JAPANESE	12	34.4 N	168.4 W	00	27	M 38	5 NM	02	1016.3	16.0	20.0	7	11.5	30	13	32.5
PRES TRUMAN	AMERICAN	12	49.8 N	138.2 W	06	16	60	5 NM	80	1001.0	9.5	8.0	9	19.5	16	9	29.5
PRES PIERCE	AMERICAN	14	34.3 N	143.9 E	06	15	55	2 NM	23	999.0	22.2	22.2	8	16.5			
LOMPOC	AMERICAN	15	30.6 N	132.1 W	06	22	35	10 NM	01	1004.7	10.0	11.0	6	23	22	10	39
PRES FILLMORE	AMERICAN	15	48.0 N	158.6 E	06	23	45	5 NM	05	986.1	5.0	6.7	6	8	27	8	13
SEALAND MC LEAN	AMERICAN	15	49.5 N	137.9 W	00	20	55	10 NM	18	991.1	8.9	9.5	5	8	23	7	13
PORTLAND	AMERICAN	15	53.6 N	139.7 W	12	26	56	5 NM	27	992.2	5.5	7.2	4	13	26	8	16
NEWARK	AMERICAN	15	57.1 N	145.1 W	18	19	50	5 NM	02	982.5	5.5	5.5	6	13	21	8	19.5
PRES FILLMORE	AMERICAN	16	45.2 N	154.5 E	06	27	45	5 NM	02	1011.0	0.0	6.0	7	10	27	12	16
PACIFIC WING	PANAMANIAN	17	51.1 N	179.2 E	18	27	M 43	1 NM	26	982.0	3.0	4.3	6	10	27	6	13
WORLD PRIDE	LIBERIAN	17	51.5 N	173.7 E	00	27	48	5 NM	23	978.5	3.0	7.0	5	13	26	6	32.5
SEALAND MC LEAN	AMERICAN	18	53.1 N	179.3 W	00	27	45	1 NM	26	976.0	2.7	3.8	5	8			
PACIFIC WING	PANAMANIAN	18	51.1 N	173.7 E	12	31	M 43	2 NM	07	1003.0	3.5	5.0	6	14.5			
WORLD PRIDE	LIBERIAN	18	49.8 N	170.8 E	00	32	46	10 NM	09	1003.0	4.0	8.0	5	11.5	27	6	29.5
PAN ASIA	PANAMANIAN	20	40.1 N	168.6 E	12	28	M 46	2 NM	03	1009.0	10.0	19.0	13	16.5	28	>13	29.5
ARCO SAG RIVER	AMERICAN	20	47.1 N	132.8 W	18	15	45	2 NM	02	1006.0	13.0	11.1	5	13			
PORTLAND	AMERICAN	20	57.0 N	145.7 W	18	10	50	1 NM	63	988.8	5.0	6.7	12	19.5	11	>13	26.5
NEWARK	AMERICAN	20	59.7 N	136.3 W	18	13	60	5 NM	50	1002.9	7.7	8.4	8	24.5			
WORLD PRIDE	LIBERIAN	20	46.0 N	157.3 E	00	33	42	5 NM	03	1005.0	5.0	6.0	5	6.5	36	< 6	23
PORTLAND	AMERICAN	21	58.0 N	148.2 W	00	08	60	1 NM	63	982.7	5.0	5.6	6	14.5	08	6	26.5
CHEVRON MISSISSIPPI	AMERICAN	21	59.1 N	132.0 W	12	09	50	2 NM	78	980.5	4.4	6.1			09	8	16.5
LOMPOC	AMERICAN	21	51.8 N	140.6 W	18	14	45	2 NM	64	994.2	6.1	6.7	4	6.5	14	6	16.5
GALVESTON	AMERICAN	21	57.4 N	151.5 W	00	06	50	1 NM	53	978.0	4.5	6.0	6	14.5	06	12	29.5
PRESIDENT MADISON	AMERICAN	23	34.8 N	171.5 W	18	29	55	2 NM	02	999.3	13.9	14.4	10	29.5			
SEALAND COMMERCE	AMERICAN	24	36.0 N	168.1 W	12	32	55	.5 NM	65	989.5	12.8	14.4	10	18	XX	X	28
ROSE	LIBERIAN	24	33.4 N	160.5 W	18	21	M 47	5 NM	03	983.5	18.5	19.0		24.5			
PRESIDENT MADISON	AMERICAN	24	34.6 N	171.8 W	00	30	60	5 NM	07	993.8	16.7	18.0	10	34.5			
AMERICA MARU	JAPANESE	24	33.8 N	169.8 W	12	33	M 38	5 NM	62	1000.5	13.0	20.0	5	16.5	33	7	19.5
ARNOLD MAERSK	DANISH	24	38.4 N	166.3 W	18	01	60	2 NM	81	993.5	12.3		8	49			
CHALMETTE	LIBERIAN	24	33.4 N	166.3 W	12	31	45	2 NM	60	985.0	14.5	17.5	7	11.5	29	9	16.5
MAMMOTH PINE	LIBERIAN	24	39.2 N	173.3 W	00	02	M 45	5 NM	01	1003.9	12.8	15.0		10	02	X	13
CHEVRON MISSISSIPPI	AMERICAN	25	57.0 N	148.5 W	00	30	45	10 NM	01	1018.5	3.3	6.7	3	8	31	6	11.5
CHALMETTE	LIBERIAN	25	32.8 N	169.0 W	00	30	50	2 NM	62	984.0	15.5	18.0	6	11.5	29	8	16.5
ARNOLD MAERSK	DANISH	25	38.0 N	165.3 W	00	01	60	2 NM	81	989.6	11.0	12.0	8	46			
ARILD MAERSK	DANISH	28	30.0 N	162.7 W	00	30	45	2 NM	01	988.0	21.0	20.0		19.5			
ASIA HOMO	LIBERIAN	28	37.9 N	168.9 W	00	33	M 45	5 NM	02	1000.1	12.0	14.0	6	39			
MAMMOTH PINE	LIBERIAN	28	39.0 N	178.4 W	12	33	M 27	10 NM	02	1004.1	8.2	14.0		13	03	X	32.5
OVERSEAS JUNEAU	AMERICAN	25	46.4 N	179.2 E	06	18	M 45	2 NM	02	1000.0	4.4	6.4	5	19.5			
VERRAZANO BRIDGE	JAPANESE	25	34.7 N	167.7 W	00	34	M 43	5 NM	02	1001.5	13.0	16.0	9	21			
SEALAND COMMERCE	AMERICAN	25	36.2 N	172.1 W	00	36	42	10 NM	02	1010.0	10.6	14.4	10	19.5			
ROSE	LIBERIAN	25	32.6 N	161.7 W	06	29	M 46	5 NM	00	986.5	16.0	19.0		28			
PRES KENNEDY	AMERICAN	25	48.1 N	149.3 W	06	09	42	10 NM	02	1018.3	3.9	6.7	5	10			
MAMMOTH PINE	LIBERIAN	26	40.0 N	158.2 W	06	29	M 55	5 NM	80	992.0	9.0	13.0			06	12	13
RUSH	AMERICAN	26	36.5 N	170.4 W	18	03	M 60	2 NM	07	989.8	0.0		10	11.5			
RUSH	AMERICAN	27	36.9 N	169.8 W	00	02	M 49	1 NM	07	985.1	- 1.0	4.2	11	32.5			
PACIFIC WING	PANAMANIAN	28	35.8 N	153.0 E	12	27	M 41	10 NM	02	1005.0	17.0	20.0	5	6.5			
ASIA BRAVERY	LIBERIAN	29	34.3 N	144.1 E	06	28	M 37	.25 NM		1004.0	16.0	24.0			29	12	19.5
OVERSEAS JUNEAU	AMERICAN	29	44.5 N	143.5 W	18	14	M 60	5 NM	50	1006.1	12.7	7.7	7	16.5			

Vessel	Nationality	Date	Position of Ship		Time GMT	Wind			Visibility n. mi.	Present Weather code	Pressure mb.	Temperature °C		Sea Waves†		Swell Waves		
			Lat. deg.	Long. deg.		Dir. 10°		Speed kt.				Air	Sea	Period sec.	Height ft.	Dir. 10°	Period sec.	Height ft.
NORTH PACIFIC OCEAN		NOV.																
ASIA BRAVERY	LIBERIAN	30	36.5 N	154.2 E	18	29	M	33	.5 NM	02	1006.5	12.0	22.0					
MAID BUTTE	AMERICAN	30	13.9 N	94.9 W	18	34			10 NM	02	1015.2	18.3	28.8			34	>13	10
GOLDEN MARINER	PANAMANIAN	30	51.5 N	168.5 E	13	11	M	46	2 NM	02	980.0	2.0	4.0	6	11.5	12	8	14.5
NORTH PACIFIC OCEAN		DEC.																
WIND ENDEAVOUR	NORWEGIAN	1	32.3 N	159.4 W	00	32	M	45	5 NM	06	1005.0	18.0	19.0	7	10	32	12	13
ASIA BRAVERY	LIBERIAN	1	37.8 N	161.0 E	18	30	M	48	1 NM	83	1003.0	10.0	21.0					
EXPORT COURIER	AMERICAN	1	13.8 N	95.1 W	06	36	M	45	5 NM	02	1013.5	21.5	24.5	6	10	36	>13	19.5
SAN FRANCISCO	SWEDISH	1	15.3 N	94.7 W	03	01		45	10 NM	02	1013.5	21.0	25.2	7	18			
ASIA BRAVERY	LIBERIAN	2	39.2 N	168.1 E	18	30	M	49	1 NM	02	995.5	9.5	18.0					
ASIA BOTAN	LIBERIAN	6	33.0 N	172.0 E	18	27	M	36	1 NM	50	982.0	19.0	18.0	6	13	13	10	16.5
EASTERN ROSE	LIBERIAN	7	42.1 N	171.8 W	12	20	M	32	1 NM	07	1000.1	13.0	13.0					
MONTIRON	LIBERIAN	7	53.9 N	177.5 E	18	07	M	47	2 NM	50	983.5	3.5	5.0	7	11.5	09	10	14.5
GOLDENROD	LIBERIAN	7	54.5 N	174.5 W	18	13	M	45	5 NM	02	1001.0	3.0	4.0	4	6.5	13	8	11.5
HONGKONG PHOENIX	SINGAPORE	7	40.1 N	170.6 E	00	30		50	5 NM	60	982.4	7.8	12.0	8	21	XX	X	16.5
ASIA BOTAN	LIBERIAN	7	33.1 N	171.4 E	00	30	M	42	5 NM	01	1001.0	19.5	17.0	6	13	30	10	16.5
SEALAND MC LEAN	AMERICAN	7	47.3 N	166.9 W	18	15		50	10 NM	02	1006.5	7.2	4.5					
PACBARON	LIBERIAN	7	39.5 N	174.5 W	06	17	M	61	.5 NM	06	1000.0	14.0	13.0	13	23			
GOLDENROD	LIBERIAN	8	54.3 N	177.0 W	00	12	M	43	1 NM	21	983.0	4.5	4.0	8	19.5	12	12	19.5
BREWSTER	PANAMANIAN	8	50.8 N	133.1 W	18	34	M	45	10 NM	03	1000.0	6.0	11.0	3	8	34	< 6	13
SEALAND MC LEAN	AMERICAN	8	49.5 N	156.8 W	12	16		48	10 NM	61	1007.0	7.2	4.5	6	10	20	7	10
HONGKONG PHOENIX	SINGAPORE	9	40.4 N	152.5 E	18	26		42	5 NM	02	999.7	7.5	11.0	8	13	27	8	23
TOYOTA MARU #12	JAPANESE	9	52.0 N	143.4 W	12	22	M	42	2 NM	07	1002.5	7.5	8.0	4	6.5	25	9	11.5
AMER TRADER	AMERICAN	9	32.8 N	143.8 E	06	27		43	5 NM	16	1004.7	13.0	21.6	5	8	23	< 6	6.5
HONGKONG PHOENIX	SINGAPORE	10	40.4 N	150.9 E	00	27		45	5 NM	01	1002.9	7.1	14.0	8	19.5	27	10	24.5
GOLDEN EXPLORER	LIBERIAN	12	43.0 N	172.4 W	06	29	M	45	10 NM	01	988.0	6.0	9.0	4	6.5	25	8	11.5
TRIUMPH	PANAMANIAN	12	34.7 N	153.5 E	04	32	M	41	10 NM	02	1019.3	14.0	22.0	7	6.5			
SANTA MARIA	AMERICAN	13	37.2 N	146.7 W	18	20		44	5 NM	03	977.0	3.4	5.5	6	11.5	20	10	23
PACIFIC WING	PANAMANIAN	13	54.2 N	149.2 W	12	18	M	50	1 NM	60	972.5	6.0	5.0	6	13	18	8	19.5
ROBERTS BANK	LIBERIAN	13	52.6 N	149.2 W	12	27		50	2 NM	07	981.0	2.9	4.0	5	19.5	23	10	19.5
PORTLAND	AMERICAN	14	49.6 N	128.0 W	00	13		41	10 NM	02	1013.2	10.0	10.0			13	< 6	13
ROBERTS BANK	LIBERIAN	14	52.8 N	152.6 W	06	23		45	10 NM	27	991.0	3.5	5.0	8	16.5			
EXPORT COURIER	AMERICAN	14	34.3 N	176.0 W	00	29	M	50	5 NM	60	1011.0	12.0	16.2	5	16.5	29	9	28
PHILADELPHIA	AMERICAN	15	57.8 N	146.3 W	12	25		45	5 NM	02	978.7	3.9	5.6	12	11.5	27	12	14.5
KOREAN MAIL	AMERICAN	15	42.4 N	175.5 W	12	14		50	5 NM	61	991.5	6.1	6.9	8	10			
HIBI MARU	JAPANESE	16	35.6 N	179.5 W	18	29	M	42	10 NM	00	1009.0	11.5	15.5					
ASIA BRAVERY	LIBERIAN	16	38.3 N	161.1 E	00	32		47	5 NM	16	1011.5	12.5	16.0	10	8	30	11	11.5
EXPORT COURIER	AMERICAN	16	36.0 N	172.9 E	12	32	M	50	5 NM	02	1011.9	11.0	14.4	5	14.5	26	9	28
SANTA MARIA	AMERICAN	18	51.0 N	136.7 W	18	12		45	.5 NM		995.9	7.8	9.4	3	11.5			
STOLT LION	BRITISH	18	37.5 N	158.5 W	00	28		41	5 NM	60	1005.5	11.0	14.0	7	11.5	27	10	19.5
SEALAND FINANCE	AMERICAN	19	38.8 N	144.4 E	06	29		55	5 NM	02	1003.8	5.6	7.2			28	12	23
PAN ASIA	PANAMANIAN	19	39.0 N	143.0 E	00	28	M	48	2 NM	03	1003.0	8.3	18.0			28	10	32.5
PRES KENNEDY	AMERICAN	19	40.4 N	172.1 E	00	31		48	2 NM	15	996.0	7.3	12.2	7	24.5	33	>13	36
QUEENS WAY BRIDGE	JAPANESE	19	41.5 N	165.8 W	06	16	M	41	2 NM	65	986.5	12.0	10.0	8	19.5	32	7	11.5
STOLT LION	BRITISH	19	38.7 N	153.0 W	00	27		48	5 NM	16	1007.3	11.5	13.5	8	19.5	27	10	32.5
PHILADELPHIA	AMERICAN	19	36.4 N	149.1 W	06	05		55	30 YD	65	976.5	4.4	6.1	5	6.5	02	>13	10
STOLT LION	BRITISH	21	42.0 N	140.2 W	00	18		42	5 NM	20	1009.5	19.0	13.0			20	10	23
ORIENTAL EDUCATOR	BRITISH	22	35.3 N	161.1 E	12	30	M	47	5 NM	01	1011.2	13.5	18.0			30	X	28
WASHINGTON	AMERICAN	23	35.6 N	144.6 E	00	22	M	46	5 NM	64	1005.1	17.5	19.4	7	13	24	11	14.5
NORBU	NORWEGIAN	23	31.4 N	176.3 W	18	30		45	10 NM	03	1015.5	15.0	15.0					
PHILADELPHIA	AMERICAN	24	52.8 N	134.3 W	12	13		45	2 NM	61	1007.1	7.8	10.0	8	6.5	15	13	10
ZIM TOKYO	GERMAN	24	34.4 N	157.3 W	12	27		44	5 NM	00	1006.5	11.0	16.7					
WASHINGTON	AMERICAN	24	37.8 N	156.9 E	06	30	M	42	10 NM	02	1012.5	8.5	12.2	8	13			
NEWARK	AMERICAN	24	37.0 N	149.5 W	18	10		50	5 NM	25	982.1	3.8	5.5			09	8	19.5
GRAND CARRIER	LIBERIAN	24	34.7 N	159.2 W	12	25	M	55	1 NM	09	1009.2	15.0	16.0					
ASIA BRAVERY	LIBERIAN	24	32.4 N	135.5 W	12	13	M	51	.5 NM	92	997.0	8.0	10.0					
PACIFIC WING	PANAMANIAN	25	34.8 N	152.0 E	12	14	M	48	5 NM	07	1011.0	16.0	15.0	5	8			
ORIENTAL EDUCATOR	BRITISH	25	36.7 N	174.0 W	00	21	M	44	5 NM	03	1011.5	16.0	17.0	6	13			
MAMMOTH PINE	LIBERIAN	25	38.5 N	140.7 E	18	14	M	45	5 NM	01	993.0	9.2	15.0					
GRAND CARRIER	LIBERIAN	25	34.1 N	161.6 W	00	26	M	50	10 NM	02	1023.2	12.5	15.0					
MAYA PIONEER	JAPANESE	25	43.0 N	170.0 W	18	23	M	55	10 NM	18	985.0	9.0	8.0	10	41			
NORMACSTAR	AMERICAN	25	36.8 N	152.8 W	00	32		50	2 NM	62	1006.0	7.8	13.9	9	24.5	XX	X	21
PACIFIC WING	PANAMANIAN	26	35.1 N	162.8 E	18	18	M	47	.25 NM	07	1004.0	18.0	19.0	6	10			
TRIUMPH	PANAMANIAN	26	37.4 N	157.2 E	00	16	M	44	.5 NM	80	1004.8	11.0	13.0	5	6.5			
ORIENTAL EDUCATOR	BRITISH	26	37.1 N	163.6 W	00	24	M	49	2 NM	02	1000.0	10.5	18.0	9	16.5	21	9	16.5
GRAND CARRIER	LIBERIAN	26	33.7 N	168.0 W	00	25	M	55	1 NM	05	1011.1	18.0	14.0					
MAYA PIONEER	JAPANESE	26	42.2 N	170.1 W	00	04	M	50	1 NM	21	983.8	8.0	8.0	9	46	34	10	46
NOPAL SEL	NORWEGIAN	27	50.8 N	144.1 W	00	16	M	45	2 NM	60	986.0	8.0	8.0	5	11.5	15	>13	13
IDAHO	AMERICAN	27	34.8 N	142.2 E	06	27		47	5 NM	03	1001.2	10.6	18.9			27	9	28
ORIENTAL EDUCATOR	BRITISH	27	37.4 N	153.3 W	00	28	M	44	5 NM	25	1009.8	10.5	11.0	9	13	28	12	16.5
GOLDEN MARINER	PANAMANIAN	27	44.8 N	136.7 W	06	29	M	44	3 NM	05	986.6	4.0	7.5	6	10	30	9	18
ASIA BRAVERY	LIBERIAN	27	34.1 N	157.4 W	00	02	M	52	200 YD	47	973.0	2.5	6.0	3	10	02	11	19.5
CORAL ARCADIA	LIBERIAN	27	34.1 N	158.6 W	12	35	M	44	2 NM	83	976.0	0.0	4.5	8	19.5			
ARCTIC TOKYO	LIBERIAN	27	30.1 N	159.8 E	18	02	M	45	200 YD	69	980.0	- 1.0	4.0					
PRES JEFFERSON	AMERICAN	28	32.0 N	148.0 W	06	23		50	5 NM	06	980.0	3.3	3.3	5	14.5	23	8	26
NORBU	NORWEGIAN	28	32.9 N	157.8 E	06	28		45	10 NM	02	1001.0	17.0	16.0					
MONTIRON	LIBERIAN	28	37.5 N	155.9 E	06	27	M	44	5 NM	02	992.1	10.2	19.0	6	16.5	27	12	24.5
ARCTIC TOKYO	LIBERIAN	28	49.1 N	158.0 E	00	02	M	48	50 YD	69	974.0	0.0	5.0					
PRES JEFFERSON	AMERICAN	30	33.7 N	177.7 W	18	07		45	10 NM	03	963.1	2.2	2.2	4	8	05	8	16.5
SHUNWIND	LIBERIAN	30	45.1 N	152.8 E	00	29	M	45	5 NM	26	997.0	0.0	6.0	5	10	01	9	19.5
NORBU	NORWEGIAN	30	34.3 N	145.0 E	18	29		55	> 25 NM	00	1008.0	11.9	15.0					
DAISHOWA VENTURE	LIBERIAN	30	53.7 N	175.0 W	00	07	M	52	1 NM	72	989.0	1.0	2.0	8	16.5	07	12	16.5
ATLANTIC PIONEER	PANAMANIAN	30	51.2 N	150.5 W	06	11	M	45	1 NM	00	994.0	5.0	3.0	7	13	11	12	13
ZIM TOKYO	GERMAN	31	34.4 N	147.4 E	06	32		47	10 NM	25	1009.0	9.5	18.0	8	23	31	7	26
GLORIOUS SHINKO	LIBERIAN	31	29.4 N	160.5 E	12	27	M	45	5 NM	25	1008.4	19.0	22.0	10	10	29	12	16.5
GRAND CARRIER	LIBERIAN	31	33.2 N	158.3 E	06	26	M	45	> 25 NM	03	1000.0	15.9	18.0					

† Direction for sea waves same as wind direction
X Direction or period of waves indeterminate
M Measured wind

NOTE: The observations are selected from those with winds ≥ 35 kn or waves ≥ 25 ft from May through August (≥ 41 kn or ≥ 33 ft, September through April). In cases where a ship reported more than one observation a day with such values, the one with the highest wind speed was selected.

(Continued from page 196).



Rough Log, North Atlantic Weather

February and March 1977

ROUGH LOG, FEBRUARY 1977--There were two primary storm tracks over North America this month, and they converged into one south of Newfoundland. This combined track traced a path eastward to near 35°W and turned northeastward toward Iceland, where the storms generally dissipated or curved back westward. Only one significant storm penetrated into the Norwegian Sea and that originated off Ireland. Two storms made the long voyage from the east coast of the United States all the way to Europe. Normally, there are tracks into the Davis Strait and Denmark Strait. These were missing this month, except for isolated short-lived LOWs.

The sea-level pressure and pressure-level height means at least partially explain their behavior. The primary Icelandic Low was deeper than normal this month, and it was located southeast of its climatic position--992 mb near 55°N, 30°W. A secondary LOW east of Nordkapp, Norway, was only a trough in the mean picture. The Azores High was 6 mb higher than normal, but it was normally located near 29°N, 30°W.

In the upper-air picture at 700 mb a LOW was 10° longitude west of its surface counterpart. This was an anomalous Low, as the primary one was far north over the Queen Elizabeth Islands. There was also an anomalous High at 70°N off the east coast of Greenland and north of Iceland.

These differences from climatology resulted in some large anomalies. At both the surface and upper air, there were large negative anomaly centers in the vicinity of 50°N, 20°W. The area over the Norwegian, Greenland, and Barents Seas was dominated by positive anomaly values.

Extratropical Cyclones--On February 1 there were several small cyclones across the shipping lanes, but none were strong. For a winter month the area of flat gradient over Nova Scotia and Newfoundland was

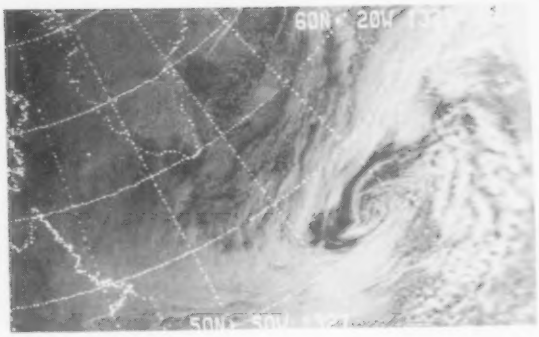


Figure 61.--Clouds cover the shipping lanes from North America to Europe.

large. This could not exist for long; and by 1200 on the 2d, a LOW had formed over Cape Race. Gale-force winds began blowing almost immediately. A ship south of Cape Race had 25-ft swells.

At 1200 on the 3d, the 970-mb LOW was near 46°N, 40°W. The FNGK was at 34°N, 31.5°W, with 80-kn winds and 25-ft waves. Other ships with 50- to 60-kn winds were the MUENCHEN, T. AKASAKA, and KCMH, with the later reporting 33-ft waves. Twelve hours later on the 4th, the OGDEN WABASH battled 83-kn winds off the U.S. East Coast. Closer to the 958-mb LOW, the STEPHANITOR was sailing into 60-kn winds and 33-ft seas about 550 mi south of the center, while the ELBE EXPRESS was only about 60 mi from the center with 60-kn winds and 30-ft seas. At 0600 she reported only 52-kn winds, but the same seas. From 0600 to 1800 (fig. 61) the TILLIE LYKES was sailing westward about 120 mi south of the center. She suffered 65- and 75-kn winds with 30-ft seas for those three observations as she moved into the southwest quadrant. A note attached to her observation form indicated the barometer bottomed out at 957.3 mb at 0200 at 49.3°N, 36.2°W (fig. 62). Winds were gusting to 105 kn with squalls. The seas were mountainous and confused with horizontal spray with the seas often obscured from the bridge. At the same time many other ships farther from the center were reporting winds in the 40- and 60-kn range and up to 25-ft waves.

The central pressure was on the rise by the 5th,

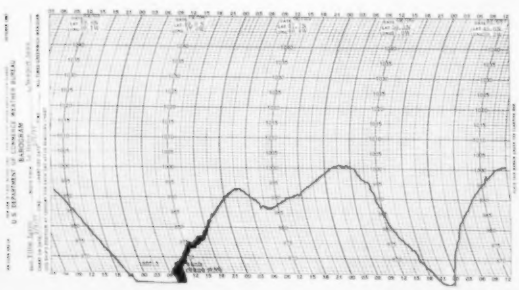


Figure 62.--The barogram from the TILLIE LYKES bottomed out at 960 mb, while the pressure continued to drop to 957.3 mb.

and transient LOWs were further weakening the storm. The MANCHESTER COURAGE had 45-kn winds not far from the center, at 48.2°N, 31.4°W, with battering 25-ft seas and 38-ft swells. Later that day they just disappeared.

This storm formed near Wheeling, W.Va., on the 5th. The AMERICAN RANGER was about 300 mi south of the center as the LOW moved eastward with 56-kn winds. OWS Hotel measured 48-kn winds after frontal passage. By 1200 on the 6th, the storm had a 962-mb center at 44°N, 59°W. The EL TAINO was about 400 mi south of the center at 36.8°N, 60.7°W, when struck by 60-kn westerly winds and monstrous 57-ft seas. Gales were blowing elsewhere driving seas up to 25 ft. At 1200 on the 7th, the ROMAN PAZINSKI (44.4°N, 47.6°W) had balmy 48-kn winds, and 36-ft swells were pounding her port side.

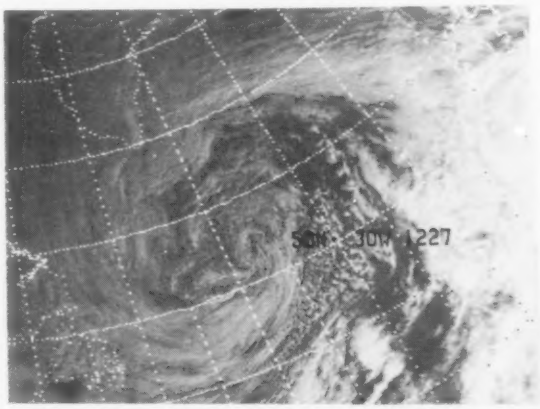


Figure 63.--At 1227 the large storm was centered near 52°N, 37°W. The clouds indicate the vastness of its circulation.

The 1200 chart of the 8th showed the large 954-mb storm spanning the North Atlantic from shore to shinning shore (fig. 63). The ASIA FREIGHTER was in the wrong seas with 60-kn southwesterlies at 46.4°N, 31.8°W. The swells were rolling by at 57 ft. On the 9th the high winds and seas continued. The POST CHARGER was hammered by 41-ft swells. In the approximate area of 42° to 47°N and 32° to 38°W, five ships found winds of about 50 kn. The POST CHARGER now had 46-ft swells, and the ASIA FREIGHTER had 49-ft swells. At 1800 two more ships in the area found high winds and waves--the ANONA, 64 kn and 46 ft; and the TAUPO, 50 kn and 56 ft.

At this time the center was weakening and tracking eastward along 55°N. Winds and seas were decreasing as the storm split into multiple LOWs. There were still winds in the 40-kn and seas in the 20-ft category. On the 13th, the storm dissipated off Ireland.

This was a fast developing frontal wave that first appeared on the 1800 chart of the 16th off Cape Hatteras. The storm moved northeastward. On the 17th at 1800, the DIETRICH OLDENDORF, near 38°N, 56°W, was tracking into 60-kn winds and 33-ft swells. At 0000 on the 19th, the whirlpool of a storm was 956 mb cen-

tered near 49°N, 40°W. The NORD was about 200 mi east of the center with 60-kn winds from the southeast. The Canadian ship VGLV was even closer to the center with 47-kn winds and 25-ft seas. At 1200 a ship had 55-kn winds with 49-ft seas and swells near 42°N, 33°W. The S. KATHARINEN, 500 mi southwest of the center, battled 60-kn westerly winds and 26-ft waves. Waves in the 20- to 25-ft class were south of the LOW (fig. 64).

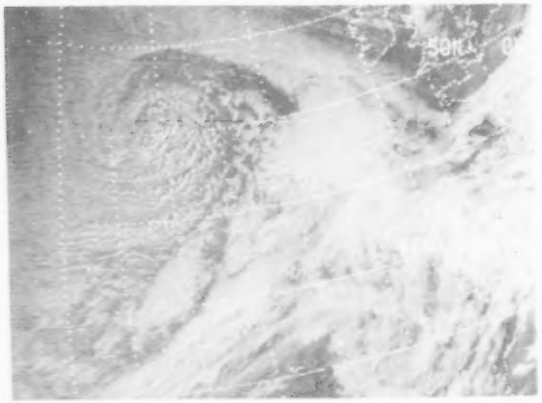


Figure 64.--The center of the storm was in the west and darker side of this satellite track, but it can be identified near 51°N, 32°W.

One cyclonic circulation again dominated the North Atlantic shipping lanes. As the storm crossed the 20th meridian at 53°N on the 20th, the MAYA was crossing the 19th meridian near 43°N with 90-kn winds on her starboard bow. OWS Romeo measured 31-ft seas.

At 1800 the C.P. DISCOVERER was headed westward directly into 55-kn winds and 46-ft seas. The TRIDENT ROTTERDAM not far away had 45-kn winds and 33-ft seas. OWS Romeo was fighting to stay on station with 45-kn winds and 43-ft seas. The storm was traveling slowly as it approached the English Channel and stalled for clearance for 24 hr below Ireland on the 22d and 23d. The DISCOVERER still had 43-ft swells on the 21st. Winds of 40 to 50 kn and seas up to 30 ft were still being reported south and west of the center.

On the 23d the storm was wearing itself out with friction over the land, but it still managed to cross into the North Sea.

A large, deep, cold LOW moved up the east coast of the United States and was off Labrador on the 22d. A cold HIGH was over central Canada, and this LOW formed over western Quebec in the col area south of and between the pressure centers. As the first LOW moved northward over the Labrador Sea, the new one moved eastward. The first gale-force winds were reported by St. Pierre Island on the 24th. By 1200 the storm was over warmer, more friendly waters near 52°N, 42°W, at 974 mb. The storm passed over the AMERICAN CHALLENGER, and she suffered 50-kn thunderstorm winds with 16-ft seas and swells. Ocean Weather Station Charlie, east of the center, had 45-kn winds and 16-ft seas. The MANCHESTER CRUSADER, 360 mi southwest of the storm's center, was sailing into 33-ft seas and 36-ft swells. At 1800 the C. P. DISCOVERER was pounded by 39-ft swells. Winds of strong gale and storm force were found in the southern half of the storm.

The 1200 chart of the 25th showed the LOW split into three centers (fig. 65). The DART AMERICA had 50-kn winds and 23-ft seas on her bow. Another British ship had 33-ft swells east of the center. At 0000 on the 26th, the DART AMERICA (44°N, 43°W) still had 50-kn winds, but the swells were 39 ft. The ORDUNA was more south of the center and had 41-ft swells. Two ships reported 60-kn winds at 1800. On the 26th the storm was weakening, and the high waves had rotated to the eastern quadrant of the storm. On the 27th a new LOW moved in from the southwest, and one of the transient LOWs became the main center.

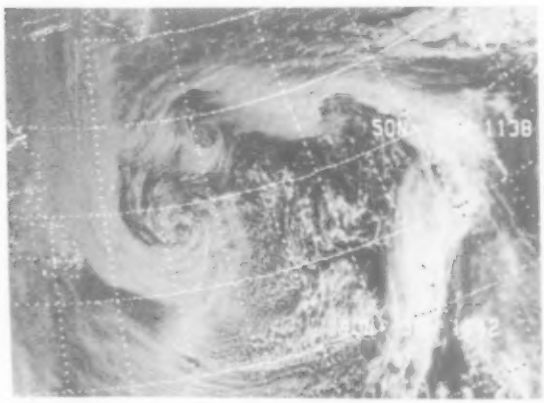


Figure 65.--The three centers according to this imagery were near 49°N, 43°W; 54°N, 39°W; and 53°N, 26°W, at 1138. On the 1200 surface chart, these centers were slightly different.

This storm formed near 40°N, 56°W, on the 26th at the occlusion of a frontal system that stretched eastward from a LOW off Maine. The ORDUNA was headed toward the East Coast with 50-kn winds, 39-ft seas, and 33-ft swells. By the 27th the storm was expanding its area of influence, and at 1200 it was 978 mb at 41°N, 37°W. Gales with waves to 25 ft were being reported, with the TOYOTA MARU battling 33 ft near 36°N, 51°W. At 0000 on the 28th, the few winds reported were not high, but the swells were 33 and 36 ft about 900 mi out in the southwest quadrant.

On March 1 the LOW turned northward toward Iceland, and another LOW formed in the trough 1,000 mi to the south. The CUNARD CHAMPION was off Fastnet Rock with 25-ft swells. The NORTHERN was about 200 mi north of the center on the 2d with 50-kn easterly winds and 26-ft seas. On the 3d the LOW turned westward to stall and fill.

Casualties--The 15,914-ton tanker FIONA JANE became icebound on the 3d in the Gulf of St. Lawrence and sustained a 2-ft fracture of the port side shell plating. The American barge ETHEL H., loaded with 60,000 barrels of heating oil, struck a submerged ob-

ject in the Hudson River on the 4th. The barge ran aground and, partially submerged, leaked oil into the river. Cleanup was hampered by heavy ice on the river.

The AMERICAN ARCHER (15,864 tons) was at Hamburg on the 8th with heavy weather damage. The 48,320-ton tanker OSWEGO GUARDIAN was surveyed afloat in the Delaware River during the first week of the month for heavy weather damage that occurred in January.

Early in the month a 6,592-ton Greek freighter parted its towline in bad weather near Brindisi and went aground. About midmonth the 22,189-ton VOLNAY was at Houston for survey and repair of heavy weather damage.

An engineer was killed and 29 crewmembers abandoned the burning 2,350-ton East German freighter INSELBERG after a collision with the 3,200-ton Finnish cargo ship BORE 11 in thick fog northwest of Bornholm.

ROUGH LOG, MARCH 1977--The paths of the low-pressure centers did not match the climatological paths very well this month, even though the configuration of the mean-pressure pattern matched very closely. The mean storm path from the Midwest to over the Great Lakes was normal, and the storms quickly dissipated northeast of the Lakes instead of continuing toward Davis Strait and Iceland. There was the normal storm path off the east coast of the United States, but it took a more easterly component away from Newfoundland than is usual. Near 35°N the storms turned northward to generally dissipate south of Iceland. More storms than usual formed in mid-ocean to track toward Iceland.

The Icelandic Low was near 57°N, 30°W, slightly east of its normal location at 998 mb rather than the normal 1005 mb. A secondary 1007-mb LOW was just north of Norway. The Azores High at 1024 mb was normally located near 30°N, 30°W, but it was 4 mb higher in pressure. Anomalies were mainly caused by pressure differences rather than center locations. A negative 8-mb center was near 55°N, 27°W, and a positive 4-mb center was near 30°N, 30°W. Probably the most significant pressure center (1008 mb) and anomaly (-7 mb) was over the Great Plains.

As usual, the upper-air pattern was mainly zonal over the water. There was an anomalous low-pressure center south of Kap Farvel. This shifted the major trough line from a north-south orientation to northeast-southwest off the eastern coast. The Low over the Midwest was reflected in the upper air by a short-wave trough. The normal ridge over the coast of western Europe was shifted eastward.

Extratropical Cyclones--The first week of the month the weather over the water was dominated by two high-pressure areas, one over the Mediterranean Sea and the Bermuda High. The LOWs were between the two HIGHs and to the north, where they were weak and small in relative terms.

This LOW formed in a trough between the two HIGHs late on the 4th. On the 6th it combined with the circulation of two other LOWs to become a large storm heading northward. At 1200 it was 970 mb with gales to the south and west. There were also swells up to 20 ft. At 0000 on the 7th, Ocean Weather Station Charlie measured 48-kn winds with 25-ft seas from 240°. Another LOW from off the U.S. East Coast was rapidly overtaking this one.

This was the LOW. It formed at a frontal occlusion on the 5th. It rolled rapidly around the periphery of the previous LOW with gale-force winds and moderate seas. Things picked up on the 7th. Three ships reported winds of over 60 kn. They were the FRANKFURT, NORDIC TEXAS, and TOLUCA. The seas were running up to 25 ft as reported by the EXPORT DEMOCRACY near 39°N, 38°W.

At 1200 on the 8th, this LOW overtook and absorbed the previous one with many 40-kn winds reported in the southern half of the circulation. The VANCOUVER FOREST, 900 mi south of the 962-mb center, was surfing toward the northeast on 33-ft swells. Along the front there were 20- to 30-ft waves (fig. 66).

On the 9th, another vicious LOW was moving eastward south of this LOW and weakening the gradient between the two. The LOW had turned toward the northwest, but it took a sudden turn to the northeast after midday on the 9th. It was gone on the 10th.

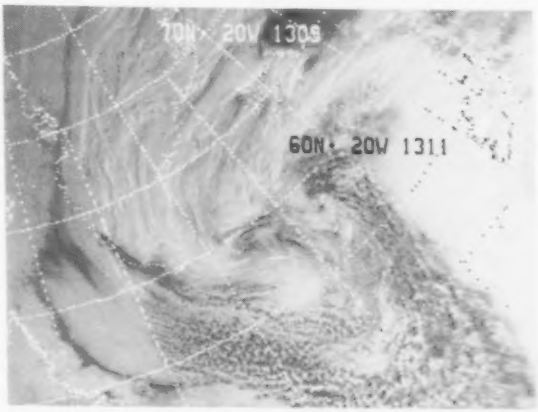


Figure 66.--This satellite imagery indicates that there still may have been two centers of circulation at 1312. The western one is probably the upper-air circulation.

Monster of the Month--A wave formed on the 6th near Savannah, Ga., on the front that stretched southwest-

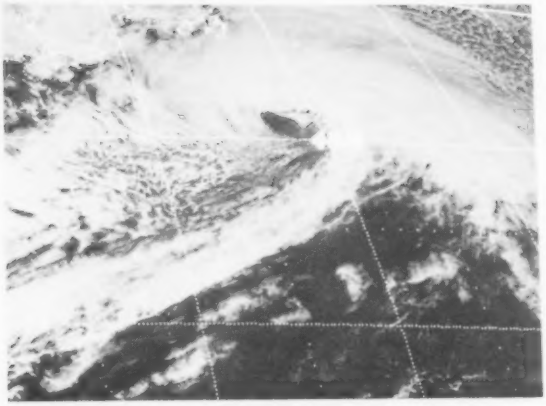


Figure 67.--This SMS image at 1700 on the 8th shows the storm with a hurricane-type open eye near 41°N, 52°W.

ward from the LOW above. At 1200 on the 7th, it was over the Gulf Stream off Cape May. The TOLUCA was east of the center with 60-kn winds and 20-ft seas. By 0000 on the 9th, the circular 969-mb storm was near 43°N, 45°W (fig. 67). The FRANKFURT (41°N, 47°W) reported a roaring hurricane-force 70-kn wind with 59-ft seas and swells. A SHIP reported 40-kn winds and a pressure of 969.1 mb in the center of the storm.

At 1200 the SEA-LAND MARKET was 180 mi southeast of the center of the LOW sailing eastward with the aid of 60-kn winds and 25-ft seas. The ONLA was headed into giant 49-ft seas and 56-ft swells driven by 55-kn winds while 420 mi southwest of the center. The VANCOUVER FOREST (45°N, 29°W), east of the center, had 36-ft seas and swells. The HOEGH PILOT (39°N, 42°W) pounded into 46-ft seas. The high winds and seas continued with the DART AMERICA reporting 41-ft swells later in the day. At 0000 on the 10th, Ocean Weather Station Romeo measured 50-kn winds and 26-ft seas. The DART ATLANTIC was plowing into 40-ft swells, which were also battering the MUENCHEN. On the 11th the 960-mb LOW was south of Iceland and turning westward. Swells of 20 ft were still being reported as far as 1,000 mi southwest of the center. The KOSICE was near that 1,000-mi mark (43°N, 20°W) with 60-kn winds and 23-ft seas at 1200. On the 12th another LOW moved south of this LOW, and it again turned eastward to dissipate near Iceland on the 13th. The southern LOW produced winds of near 55 kn and swells of 33 ft for both the AMERICAN LEGACY and the C.P. TRADER near 48°N, 36°W.

This was a severe storm over the North Pacific that tracked across northern Canada to move off the Labrador coast on the 13th. The C.P. TRADER ran into this storm at 0000 on the 14th and found 40-kn winds, 20-ft seas, and 38-ft swells. At that time the LOW was 982 mb near 51°N, 36°W. Later in the day the storm turned northward. Many ships were reporting gales with seas and swells in the 20-ft category. At 1200 the AMERICAN ARCHER about 40 mi southsoutheast of the center, experienced 60-kn winds and 25-ft seas. On the 15th the ATLANTIC SPAN (49°N, 40°W) suffered 55-kn northerly winds with 30-ft seas. Six hours later at 1200 the seas were 39 ft and then 33 ft at 1800.

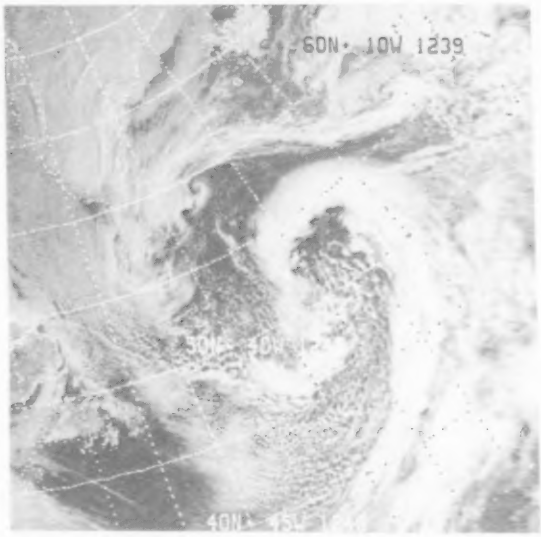


Figure 68.--The frontal clouds have wrapped around the storm on the 14th. A smaller LOW is centered northwest of Ireland.

The LOW covered the shipping lanes from Newfoundland to Europe, and there were high seas from 50°N to south of 40°N (fig. 68). The high seas continued until the 18th with 20 ft the general height with an occasional 30 ft.

During the 16th to the 18th, the storm center wandered north and south as it gradually moved eastward. Late on the 18th, it decided on a southeasterly track, pausing near Paris for 2 days, and then dying out on the 23d on the south coast of France.

The lee of the Rocky Mountains produced this storm on the 17th. By the time it reached the East Coast it was fully developed. At 0000 on the 19th, it was off Long Island, and Ocean Weather Station Hotel had 50-kn winds at frontal passage. At 1200 the EXPORT PATRIOT was near the warm front with 50-kn southerly winds and 20-ft waves, while the LEONARD DA VINCE, south of the 968-mb center, had 52-kn westerly winds and 30-ft seas. At 1800 the AMERICAN ARCHER encountered 49-ft swells.

At 1200 on the 20th, the 970-mb LOW was off Hamilton Inlet. The ANCO TEMPLAR was about 800 mi south of the center with howling 75-kn winds. A ship south of Kap Farvel reported easterly 68-kn winds.

The storm moved through Baffin Bay on the 22d to disappear on the 23d.

An occluded front moved eastward from the lower Mississippi valley. On the 20th a wave formed at the occlusion and moved over Cape Hatteras. The SWEDISH WASA had 48-kn winds southwest of the center at 1200, and the ASIA FREIGHTER had 60-kn northwesterlies and 30-ft waves, 120 mi southwest of the 994-mb LOW at 1800. As the storm passed south of

Newfoundland, it expanded. At 0000 on the 22d, the VANCOUVER TRADER was caught by 55-kn winds from the west and 39-ft seas. Throughout the day ships were reporting winds up to 60 kn and waves to 40 ft.

On the 23d a ship reported 55-kn winds with 43-ft waves. The KOSICE was 500 mi south of the LOW with 85-kn winds. The LOW was weakening on the 24th, but it was still producing 40-kn winds and seas to 20 ft. On the 27th, it drifted ashore near Cherbourg.

Another LOW from the east slope of the Rocky Mountains formed on the 21st and was over Long Island at 979 mb at 0000 on the 23d. Winds gusted up to 75 kn with 25 in of snow in Connecticut, and Atlantic City, N.J., had 50 kn. Storm warnings were posted along the northern New England coast with gale warnings south to Cape Charles. The 10,262-ton OCEAN ENDURANCE reported a shift in cargo near 34°N, 59°W. OWS Hotel braved 50-kn winds at 0600 with no wave report, but at 1200 the waves were 23 ft. There were half a dozen reports of winds near 45 kn and/or seas to 20 ft. On the 24th the EXPORT COURIER, 350 mi south of the 978-mb center, had mild 35-kn winds, but the seas were 16 ft and the swells 33 ft.

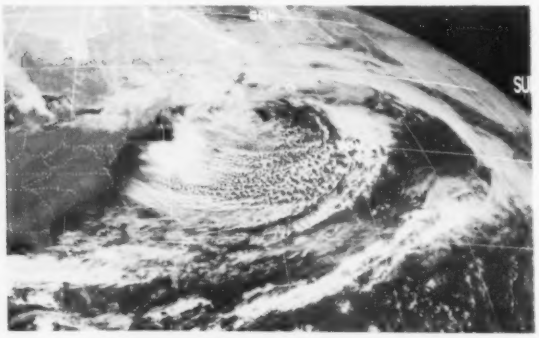


Figure 69.--This LOW off Nova Scotia has a circular flow with what appears to be two frontal systems to the east and south. Note how the clouds develop as the cold air moves over the warmer water off the coast.

As the previous LOW weakened and moved eastward, this LOW expanded. Maximum waves were 25 ft on the charts of the 25th with winds generally about 40 kn (fig. 69). The ARTHUR MIDDLETON was near 36°N, 63°W, when hit by 60-kn westerly winds, 30-ft seas, and 34-ft swells on the 26th at 0000. On that analysis another LOW formed east of this one and took over the circulation on the 27th. That day OWS Lima suffered 45-kn easterly winds, 16-ft seas, and 26-ft swells.

This storm almost missed the month. For several days there had been a series of LOWs in a trough between the Azores High and its extension over Europe and the Bermuda High and Greenland High. Late on the 29th another LOW formed east of Newfoundland near longitude 35°W. This one quickly deepened and developed into a major storm. Its pressure was 966 mb by 1200 on the 30th. The center was near OWS Charlie, which registered a pressure of 969.6 mb with 50-kn winds. The C.P. DISCOVERER, about 200 mi to the south, had 40-kn winds blowing 23-ft seas.

On the 31st the LOW was moving northeastward. The GODAFOSS fought 50-kn winds north of Charlie and northwest of the LOW's center. The ATLANTIC SPAN was south of the center at 50°N sailing into 50-kn westerly winds and 36-ft seas. East of the center gales of 35 to 40 kn were blowing over the British Isles. Forty- to 50-kn winds continued throughout the day. OWS Lima was rocked by 25-ft waves which continued into April 1. On the 2d, the LOW moved into Scandinavia and soon was no threat to shipping.

Casualties--The 15,864-ton AMERICAN ARCHER reported heavy weather damage on the 3d. The Greek motor vessel EUROSKY sustained possible ice damage while leaving Cornerbrook, Newfoundland. A collision in fog in New York Harbor damaged both the 9,322-ton American SANTA BARBARA and the 28,570-ton Italian AMBRONIA. The ATLANTIC SKOLL (15,751 tons) put into St. John's on the 8th to repair ice damage. The Finnish MISTRAL (15,743 tons) arrived St. Michael's on the 15th with heavy weather damage. The Belgian HASSELT (16,250 tons) grounded in dense early morning fog in the River Scheldt on the 23d.

Rough Log, North Pacific Weather

February and March 1977

ROUGH LOG, FEBRUARY 1977--The primary area of cyclogenesis this month was shifted to the east-central ocean along approximately 40°N from 180° to 150°W. These storms generally tracked northeastward then northward into the western Gulf of Alaska, some curving northwestward. Those storms that formed in the area of Japan had more easterly tracks than normal and were sparce--averaging only about one per week.

This shift in storm tracks was reflected in the mean pressure. A 984-mb Aleutian Low was centered at 53°N, 170°W. This was 15 mb lower than the climatic 999-mb Low near 50°N, 180°, and another 1000-mb Low 10° longitude to the west. The Pacific High off the California coast was normally located near 30°N, 130°W, but it was 6 mb higher in pressure at 1026 mb. The high pressure cell normally centered over the northwestern United States was also 6 mb higher in pressure at 1025 mb.

The shifting of more intense pressure centers resulted in one large negative anomaly of 19 mb and two positive centers of 5 and 6 mb. The negative anomaly

was centered near 55°N, 168°W, and dominated the ocean shore to shore north of latitude 30°N, except off the U.S. West Coast. The positive 5-mb center was near 34°N, 128°W, off the California coast and the 6-mb center was north of the Great Salt Lake.

The upper-air center of circulation was shifted from the Kamchatka Peninsula to over Adak Island and over 100 m lower in height for the 700-mb surface. The ridge over the Rocky Mountains was much sharper than normal causing a strong, cold northwesterly flow over the central and eastern United States.

Extratropical Cyclones--A large LOW developed over the central ocean the last day in January and continued deepening. By 0000 February 2, it was 950 mb near Unimak Island (fig. 70). On that analysis a secondary LOW formed 700 mi to the south near 44°N, 166°W. This quickly tightened the gradient south of that latitude. The MEDELENA was 550 mi to the southwest and was caught by 80-kn hurricane-force winds with 16-ft seas. The CRYSTAL REED was 300 mi southeast of the 966-mb center, just east of the front and sailing with 30-ft seas and swells pounding her starboard side. On the 3d the LOW was absorbed into the main circulation. On the 4th the ANCO DUKE was caught by 45-kn winds, 41-ft waves, and 36-ft swells as a minor trough passed 35°N, 153°W.

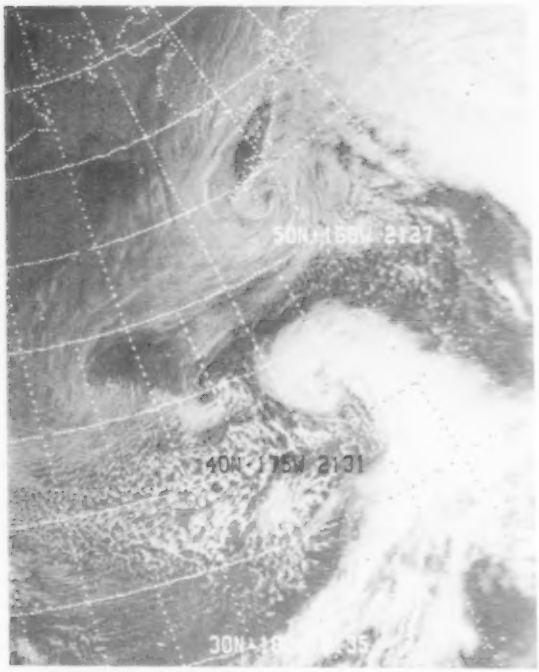


Figure 70.--The deep LOW near 54°N, 162°W, is not as clear as the secondary LOW near 43°N, 167°W, due to the low sun angle. There appears to be a third circulation near 45°N, 175°W.

As the previous storm died, another was born near 30°N, 155°E, as a frontal wave. In 24 hr it raced 20° longitude to the east and was 990 mb at 0000 on the 4th. By 1200 the 978-mb LOW had raced slightly north of a ship near 40°N, 178°W, with 65-kn winds. Back toward the east another LOW had formed and treated the KHALIDIA to 90-kn winds. On the 5th the SANKO-LIGHT was north of the deteriorating subcenter and west of the major center with 50 kn. The ATLANTIC PHOENIX was west of the eastern subcenter, which was also being squeezed out of existence, with 72-kn winds. At 0600 her winds were only 55 kn, but at 1200 they were back up to 68 kn.

Late on the 5th, the LOW traveling south of the main LOW was only a minor trough in the overall pressure pattern, but it remained identifiable until midday on the 6th.

The point of occlusion on a front was the point of origin of this storm. It was first analyzed on the 0000 chart of the 6th at 982 mb. Twelve hours prior to this, the circulation was more zonal and a ship in the area reported 28-ft swells. The FEDERAL HAGARA had 45-kn winds along the front. By 1200 on the 6th, the central pressure had plunged to 961 mb as the storm moved on a northeasterly track to 42°N, 178°E. There were several reports of 16-ft swells southwest of the center. In the next few hours, the JAPAN RAINBOW, KASUGAT MARU, and OPHELIA were to suffer winds in the 60-kn and waves in the 30-ft category to the north, west, and south of the center (fig. 71).

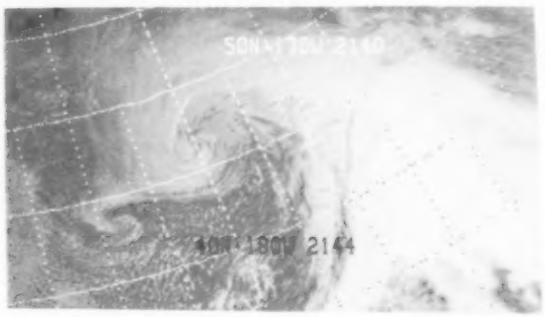


Figure 71.--The satellite caught the LOW just as it passed the International Date Line late on the 6th.

At 1200 on the 7th, the pressure dropped to 948 mb as the storm center approached Adak Island. The KASUGAI MARU continued to have 60-kn winds and 30-ft waves until the 8th. At that time the JAPAN RAINBOW reported 72-kn winds.

At 0000 on the 9th, this was the only cyclonic circulation over the northern ocean. By 1200 a subcenter had formed in a trough line south of the primary low center. The POST CHAMPION was between the two centers near 48°N, 176°W, with 86-kn westerly winds. No seas were reported. Two fishing vessels north of the center near 60°N had freezing 50-kn northeasterly winds.

On the 10th the storm was weakening and only minimal gales were reported. Other LOWs were forming and dissipating on the periphery of the primary circulation. On the 12th the storm no longer existed as another took its place.

Monster of the Month--This was one of two storms that formed south of Japan during the month. It raced eastward at up to 60 kn. The LIVERPOOL CLIPPER was south of the front early on the 11th with 50-kn winds. A Japanese-registered ship, 400 mi southeast of the fast-moving center, logged 30-ft swells. Later on the 11th, the KYOMEI MARU, 600 mi south of the 980-mb LOW and 300 mi west of Midway Island, rode out 26-ft seas.

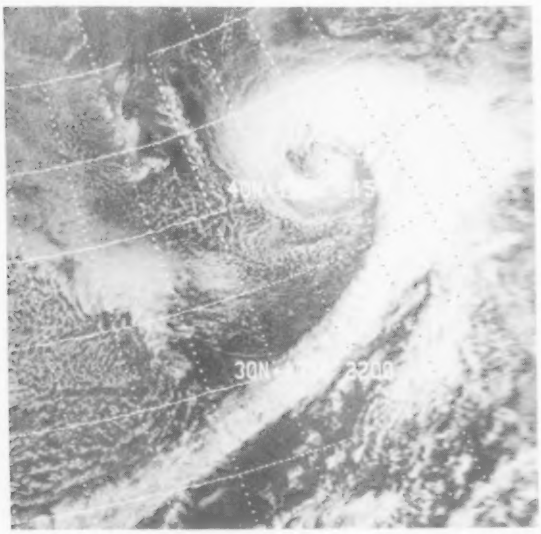


Figure 72.--As the storm slowed, it deepened and expanded its area of influence. Note the wave pattern in the northerly flow northwest of the center.

On the 12th the 956-mb LOW slowed in its plunge eastward and the winds and waves increased (fig. 72). Near the center, which was at 44.5°N, 169.5°W, the JAPAN BEAR fought 60-kn winds, 16-ft seas, and 33-ft swells after the LOW passed nearly directly over the ship. The JAPAN RAINBOW was slowly sailing westward and found 100-kn winds near 41°N, 176°E, on the west side of the LOW. Five hundred miles south of the center, the NANSHO MARU was pounding into 41-ft waves.

About 1,000 mi southwest of the LOW, there was a band of gale-force winds. The LIVERPOOL CLIPPER was caught in this area. Near 33°N, 158°E, she was headed into 33-ft seas and 49-ft swells. At 0600 the JAPAN BEAR had 49-ft swells pounding her port quarter, and they were still 33 ft at 1200. At the same time, Ocean Weather Station Papa measured 46-kn winds and 33-ft seas. At 1800 her winds increased to 80 kn.

The ROSE S sank on the 12th after sending a distress message that she was taking water in the forward hold. At the time she was about 1,200 mi off Midway Island on a voyage to Japan with a cargo of logs and scrap iron. The GLOBAL FRONTIER reported on the 13th that it had sighted drifting logs. An oil slick and deflated liferaft were also found in the area. There was no sign of the 31 crewmen. At 0000 on the 12th, the ROSE S sent a weather report from 31.1°N, 163.6°E, of 38-kn northwesterly winds and 18-ft seas and swells. At the same time the LIVERPOOL CLIPPER reported 33-ft seas and 49-ft swells about 300 mi west-northwest of her position.

Also on the 12th in the Gulf of Alaska, the GREAT LAND heard a Mayday distress signal from the fishing vessel SNOWBIRD enroute to Seattle. Severe weather conditions with swells up to 25 ft had damaged the SNOWBIRD's wheelhouse causing loss of steering and main engines. The GREAT LAND escorted SNOWBIRD to Dixon Entrance where they were met by the U.S. Coast Guard cutter LAUREL. A small LOW had spun off the east side of the main LOW on the 11th and was over the Gulf of Alaska at the time; it dissipated on the 13th.

On the 13th the GRAND CARRIER (36°N, 165°W) was washed by heavy rain driven by 65-kn winds as a trough line approached. The high winds had moved to the northeastern quadrant as this storm caught up with another in the Gulf of Alaska. There were four reports in the 50-kn category in the vicinity of 52°N, 140°W. The waves were in the 20- to 30-ft range. Later on the 13th, the high windband (50 kn) had rotated into the northern quadrant and battered the Soviet fishing fleet in the Bering Sea. Swells up to 25 ft were still found south of the center. On the 14th the CORAL ARCADIA was headed toward Seattle near 51°N, 134°W, with 76-kn southerly winds.

On the 15th the LOW crossed into the cold Bering Sea and rapidly lost its punch.

This was the other storm that was produced by the waters south of Japan. It was first noticed on the analysis of 0000 on the 14th. It did not move as fast as its earlier mate, but it deepened quicker. At 0000 on the 16th, the center was 984 mb at 40°N, 161°E (fig. 73). In a few hours the winds had increased from gale to storm force. The JAPAN RAINBOW was having a rough voyage, sailing from one storm into another. She reported 70-kn northeasterly winds north of an east-west oriented trough west of the LOW. There were reports of 50 to 60 kn south of the center and a report of 30-ft seas. At 1200 the KODO MARU (35°N, 157°E) had 55 kn. On the 17th, LOWs formed both to the east and west of this storm. By 1200 they had taken over the circulation, but at 0000 the 980-mb LOW was still producing 50-kn winds and waves to 25 ft.

Both of these LOWs produced high winds and seas. On the 17th, the western LOW was 996 mb near 38°N, 154°E. The HANS SACHS, 400 mi southwest of the

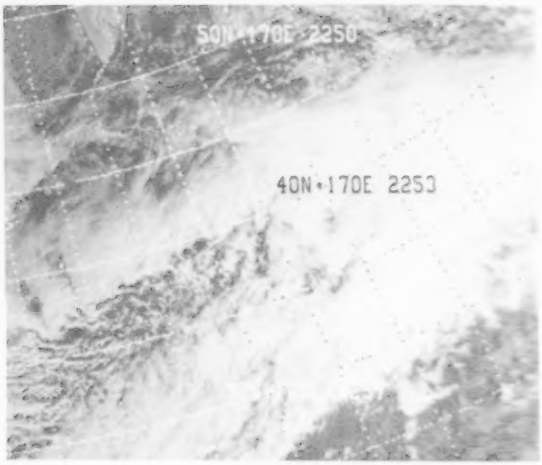


Figure 73.--The cloud pattern indicates the storm is not well organized at this time on the 15th. The surface circulation is probably hidden by high clouds.

center, braved 52-kn westerly winds and 30-ft seas and swells. Others were finding the same winds as far as 1,000 mi west of the center. On the 18th the KASHU MARU, only 60 mi south of the center, was pounded by 53-kn winds and 31-ft swells.

The 19th was a bad day to be in the area of 180° south of 42°N (fig. 74). The VAN HORNE was 100 mi south of the low center at 0000 with 50-kn winds and 39-ft seas and swells. Four hundred miles to the south, the SANG JIN also fought 50-kn winds with 30- and 33-ft seas and swells, respectively. By 1800 the LOW was only indicated by a dip in the circulation.

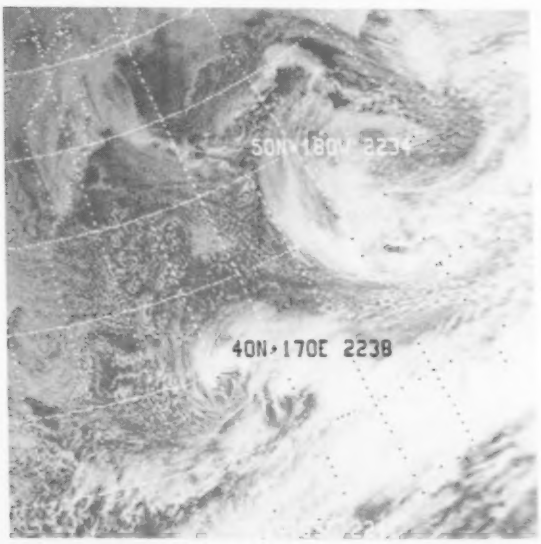


Figure 74.--The two LOWs straddling 180° made it rough for ships in the area.

Back again to the 17th. The eastern LOW deepened rapidly, which increased the pressure gradient. A ship along the front reported southerly 30-ft swells. On the 18th the pressure was 954 mb at 1200 near 46°N, 153°W. The CRYSTAL REED was caught with 50-kn winds and 33-ft seas and swells near 35°N, 152°W, at frontal passage. OWS Papa had 20-ft seas on the 19th, and another ship south of her had 25 ft. Late in the day the center crossed into western Alaska.

Rather than degenerate into a trough, this LOW developed from a trough line. At 0600 on the 19th, a closed circulation formed in the sharpest area of curvature. At 1200 the winds were blowing at better than 40 kn with one report of a heavy thunderstorm. At 1800 the CHALMETTE (35°N, 159°W) was treated to 60-kn winds. At 0000 on the 20th, there appeared to be a convention of ships near 40°N, 145°W. Five ships in the area reported winds between 45 and 50 kn. The waves were 25 to 30 ft.

The LOW reached its lowest pressure of 946 mb on the 20th near 47°N, 148°W. At 1800 there were six ships with winds over 50 kn and seas to 25 ft mostly south of the center. The storm was over the Gulf of Alaska and raising havoc with shipping. High-wind reports stretched from 37°N to 56°N. The GMDS reported 49-ft swells near 48°N, 137°W. Another ship had 39 ft near 41°N, 132°W. At 0600 on the 21st, OWS Papa measured 50-kn westerly winds and 34-ft seas. The USNS SEALIFT PACIFIC had 60-kn winds from 160° near 49°N, 132°W. At 1200 she reported seas of 36 ft, while Papa still had 30-ft seas.

Another small center formed off the coast of Washington bringing beneficial rains as far south as central California and high winds and surf to the Oregon and Washington coasts. Gusts reached 52 kn along Oregon and 85-kn gusts were observed on Vancouver Island. Swells pounding the coast were up to 20 ft.

On the 22d and 23d the storm looped counterclockwise off Kodiak Island and disappeared.

As a front moved over Japan late on the 20th, a wave formed near Tokyo. Its circulation broadened and it deepened rapidly. By 0000 on the 22d, it was 958 mb near 47°N, 160°E. The QUEENSWAY BRIDGE was about 120 mi southeast of the center with 60-kn winds from the south and 20-ft seas. The SHOZUI MARU, about 180 mi southwest of the center, had 47-kn winds from the northwest and 30-ft seas. In 6 hr, the QUEENSWAY BRIDGE only made about 30 mi on her westerly track as the seas increased to 33 ft. The 5LXR was about 180 mi to the north with 70-kn northwesterly winds and 39-ft seas.

At 0000 on the 23d, the EHIME MARU and two other ships fought winds of 60 kn or more and waves to 33 ft. Many others were reporting winds in the 50-kn and seas in the 25-ft category. These general conditions continued into the 24th, but late that day the storm was weakening over the Bering Sea. On the 24th the center curved westward and then southward on the 25th and 26th. It was still a very large storm on the 25th when the ORIENTAL EDUCATOR fought 65-kn westerly winds far to the south near 36.5°N, 174.5°E. The swells were 33 ft.

The initial wave of this storm had its origin over the Gobi Desert. It was in a hurry to leave that cold,

desolate area and moved over the Sea of Japan by 1200 on the 28th. On March 1, it was 996 mb off Hokkaido. The ALASKA MARU was about 60 mi south of the center with 40-kn southwesterlies. Later in the day, ships reported 50-kn winds. On the 2d it was on its way to becoming the primary circulation. The PRESIDENT FILLMORE was battered by 26-ft waves. A Japanese ship was pounded by 50-kn winds and 33-ft swells far ahead of the storm.

On the 3d, the 976-mb LOW was near 52°N, 172°W. The KLAK was near 54.1°N, 146.9°W, with 50-kn winds from the southwest, 41-ft seas, and 57-ft swells. Fifty- to sixty-knot winds continued into the 4th. The LOW was traveling along the Aleutian Islands and was over the Gulf of Alaska on the 4th. On the 5th it moved inland and was no longer a threat.

Casualties--The Panamanian-registered freighter TRIUMPH No. 1 (8,342 tons) developed a leak in bad weather and sank about 480 mi east of Japan. All crewmembers were rescued by the TORA MARU.

The Japanese-registered TOCAMA MARU (18,855-tons) reported that she had developed a leak in 35-ft seas while 200 mi south of the Aleutian Islands on the 22d.

ROUGH LOG, MARCH 1977--Cyclone activity over the North Pacific was near normal this month, but it was shifted in some areas of concentration. The storm centers that normally form south and east of Japan were concentrated farther north over the southern islands and took a more easterly track than indicated by climatology. Near midocean, these paths curved sharply northeastward with the majority entering the eastern Bering Sea. Approximately one-third tracked south of the Aleutian Islands into the Gulf of Alaska. The area between Hawaii, the mainland, and south of 45°N was devoid of storm-center tracks, except for two that moved southward off the west coast of the United States. There was a secondary track from northern Manchuria into the Bering Sea.

The Pacific High at 1034 mb near 36°N, 148°W, dominated the mean-pressure chart. Its center was positioned normally, but the mean pressure was 12 mb higher than normal, resulting in a 12-mb positive anomaly center. This high pressure dominated the eastern ocean during most of the month. The double-centered Aleutian Low was shifted eastward, with the eastern center (1004 mb) over Montague Island the more intense. Climatology indicates the western center (1005 mb) over the southwest Bering Sea as the more intense. This resulted in the negative anomaly centers being over southwestern Alaska and near Great Slave Lake in northern Canada. The vast majority of the ocean, except for the eastern Bering Sea and the northern Gulf of Alaska, had higher-than-normal mean pressures.

The upper air was mainly zonal flow with a major trough east of Japan and a minor trough along the west coast of the United States. Both the high- and low-height centers were more intense than normal, with the LOW shifted northeastward from the Sea of Okhotsk to west of the Bering Strait.

Tropical storm Patsy was the first tropical cyclone this year.

Extratropical Cyclones--This storm came racing across the Yellow Sea out of China as a frontal wave on the 1st. It was not until the 3d off Tokyo that it earned its title. A Ukranian ship was caught by 56-kn winds and 20-ft seas between the center and Honshu. At 0600 another U.S.S.R. ship was beaten by 64-kn winds north of the LOW. At 0000 on the 4th, the LOW was 960 mb near 47°N, 155°E (fig. 75). Fifty-kn winds were observed in the southern semicircle, with 60-kn winds north of the center. Seas of 26 ft were the highest reported. The USZY was battered by 76-kn winds among the Kurile Islands. Most of these reports must have come from the Soviet fishing fleet. The KASHIMA MARU had 50-kn winds. A 1040-mb HIGH over the central ocean blocked further eastward movement of the LOW.

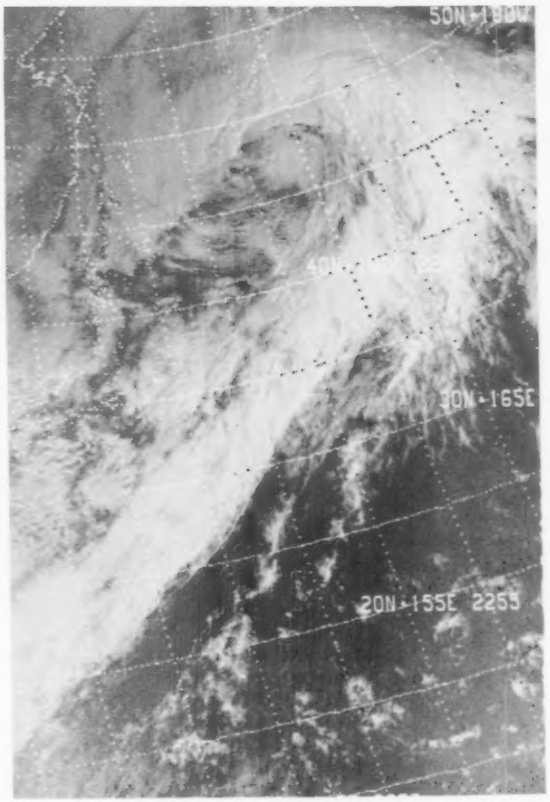


Figure 75.--At 2247 on the 3d, the center is east of the Kurile Islands near 47°N, 154°E.

This LOW formed on the east side of the previous LOW, north of the HIGH, late on the 4th. On the 5th two ships plotted winds of about 60 kn. At 1800 the PRIBOY was battered by 46-ft seas as the LOW raced eastward (fig. 76). Six hours later at virtually the same location (50°N, 160°W), the winds were 52 kn, seas 28 ft, and swells 39 ft. Another ship 6° longitude to the west was tossed around by 33-ft seas and swells. By 1200 on the 6th, the LOW was 968 mb over

the Gulf of Alaska and appeared to be heading directly for Vancouver Island, but 6 hr later it turned to the north. The PRESIDENT FILLMORE was near the Strait of Juan de Fuca with 45-kn southerly winds on the 7th. A Japanese ship was riding out 26-ft seas less than 100 mi from the low center, and EB19 reported 23-ft seas. The MEDELENA was over 1,000 mi southwest of the LOW with 64-kn westerly winds.

Figure 76.--A small dimple near 50°N, 154°W, indicates the center of this storm.

The LOW was filling as it crossed the Alaska coast on the 8th and turned eastward across Canada.

This short-wave LOW moved around the periphery of the major circulation and did not develop very large. It started late on the 5th in the Eastern Hemisphere. The LOW was racing eastward at 50 kn on the 7th. It slowed to about 30 kn on the 8th with a few gale-force winds. As it approached the coastline late on the 8th, it deepened significantly to 978 mb. The SAMUEL S. at 44.5°N, 135.3°W, was headed into 55-kn westerly winds with 23-ft seas. The AGANO MARU was closer to the coast with 46-kn southwesterlies and 33-ft swells. At 0600 on the 9th, the center crossed the coast and lost much of its power over the mountains, but the CHANTAR had 56-kn winds and 30-ft seas off the Oregon coast.

Two large areas of high pressure dominated the ocean along latitudes 30° to 35°. A weak front separated the two. At 1800 on the 8th, a wave was analyzed on the front as the two HIGHs moved eastward. By 0000 on the 9th, the storm had deepened to 986 mb as it slipped toward the north out of the grip of the HIGHs. Gales of 35 to 40 kn were now blowing. The LOW was well into the Gulf of Alaska by 1200 on the 10th, when the SEA-LAND EXCHANGE found 48-kn winds. At 1800 the SANTA CLARA (52.3°N, 137.9°W), 300 mi east of the center, was tossed by 55-kn southerly winds and 39-ft swells. On the 11th at 0000, the LOW was 956 mb at 55°N, 144°W. The SANTA CLARA and GALVESTON were within a few miles of each other near 52°N, 137°W, with 60-kn southerly winds driving 33-ft seas and 41-ft swells. Six hours later, the PRESIDENT FILLMORE, south of the center, had 50-kn westerlies with 33-ft seas and swells.

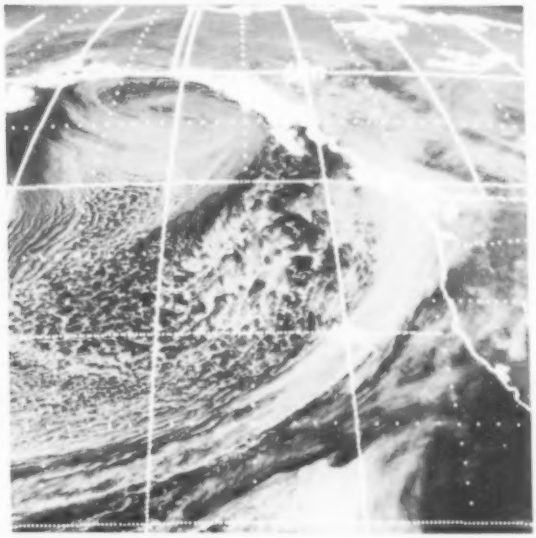


Figure 77.--From this angle the storm has the appearance of a large whirlpool. The front has crossed the coast near Vancouver Island. The clouds west of the front and south of the LOW have a pillow appearance.

After midday on the 11th, the storm suddenly turned southeastward (fig. 77). Ocean Weather Station Papa was tossed by 33-ft seas, and the NEWARK off Sitka had 60-kn winds with waves of 23 ft, while a Japanese ship was washed by 33-ft seas. As the storm moved southward, it weakened and decreased in size. A large 1047-mb HIGH, centered near 42°N, 152°W, was pressing against the coast. There were high swells on the eastern side of the HIGH, and a SHIP reported 89-kn winds (??) with rainshowers in the area. Late on the 13th, the LOW was squeezed out of existence.

The storm factory off Japan manufactured this storm. It left the assembly line late on the 11th. The LOW traveled eastward with a 1030-mb HIGH pushing and the 1047-mb Pacific High slowly retreating toward the coast. The VAN HAWK, west of the storm, radioed 56-kn northerly winds on the 13th. Later in the day, the storm turned northeastward and deepened rapidly (fig. 78). At 0000 on the 14th, it was 984 mb near 41°N, 178°E. The LAKE PALOURDE was pounded by 66-kn winds 700 mi southeast of the center, while the PEARL VENTURE and ATLANTIC PIONEER were

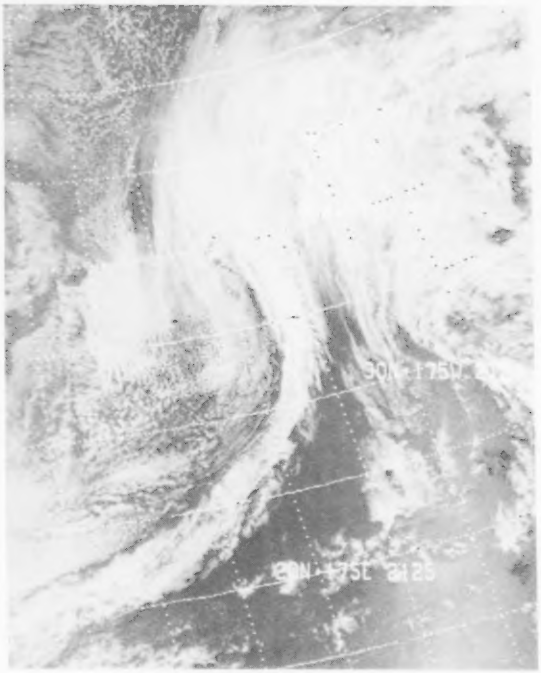


Figure 78.--The high-level clouds hide the surface LOW.

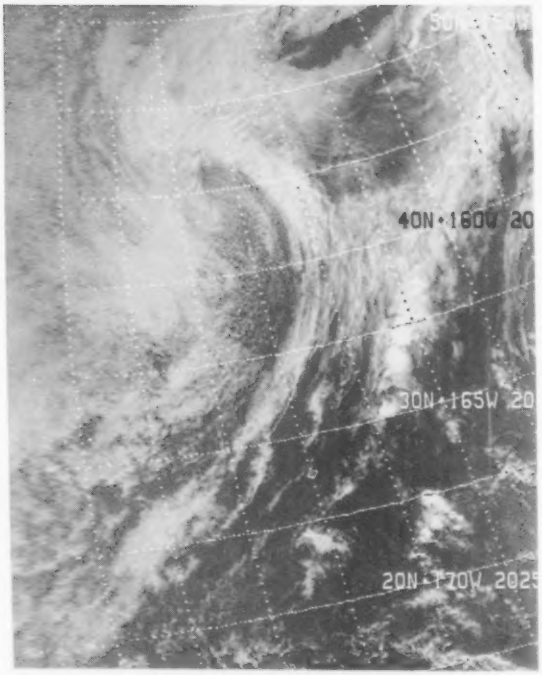


Figure 79.--The front has passed east of the TILLIE LYKES at 2022 when the satellite was overhead.

swept by 60- and 55-kn winds, respectively, in the southwest quadrant.

The storm center crossed over Atka Island early on the 15th into the Bering Sea. The pressure at that time was 962 mb. Gale force winds were reported in all quadrants with snow showers in the northern area. At 1200 the TIRASPOL, about 200 mi west of the 960-mb center, was suffering with 55-kn freezing winds and 30-ft seas. On the 17th, the weakening storm crossed onto the Seward Peninsula.

There were several LOWs or frontal waves southwest of the LOW described above. This was one of them. It originated on the 15th and followed the zonal flow, turning northeastward on the 16th as it encountered the large, stubborn Pacific High. There were isolated minimal gale reports and seas to 15 ft. At 1200 on the 17th, the 998-mb LOW was near 46°N, 176°W. A front trailed to the south to approximately 35°N and then curved southwest and westward. The TILLIE LYKES was sailing eastward near 31°N, 179°W (fig. 79). The following outstanding sketch of the radar scope (fig. 80) and comments on the passing of the front by Third Officer Judson were passed to the Port Meteorological Officer at Houston, Tex.

> 0900 17 March 1977. Clouds forming in the SW, light drizzle experienced. 0910. Windspeed increasing from SW, sky completely overcast (stratus). 0920. Heavy continuous rain, visibility 1-2 mi, radar switched on due to reduced vis., V/L encounters cold front which can be clearly seen upon the radar screen, wind veers to W force 8. 1015. Visibility increasing, sky completely overcast, light continuous rain, approximate movement of front nearly 20-25 kn. 1045. Wind NW 14 kn, barometer steady 1013.0 mb. 1130. Diagram of cold front as seen on radar. 1400. Barometer starts rising, cold front passes ship, position of ship at time of obs. 31°32'N, 179°25'W, course of V/L 090°(T) x 15 kn, temp. 14.2°C, barometer 1013.6 mb.

On the 18th the LOW was diverted into the Bering Sea. The PRIAMURYE had 52-kn winds west of the center. The ZENKOREN MARU was very near the center of the 990-mb LOW in the Bering Sea on the 19th. The wind value could not be read because of the analysis, but the swell report of 36 ft was clear. The Pribilof Islands measured 45-kn winds. There were 15- to 20-ft swell reports in the southeast quadrant. The LOW followed the Aleutian Island chain, dissipating late that day.

A series of frontal waves were rippling along a front that had been quasi-stationary south of Japan for about a week. One of these developed enough to be identifiable from the 19th to the 22d, and traveled to near midocean before dissipating. On the 21st the SEA-LAND MCLEAN found 50-kn winds just north of this center. Late on the 21st a LOW developed in a trough north of the front. By the 23d this LOW was the major LOW and center of circulation. The AGANO MARU and the VOLNA were in the vicinity of 37°N, 159°E, with 50-kn winds and seas to 26 ft. On the 24th the

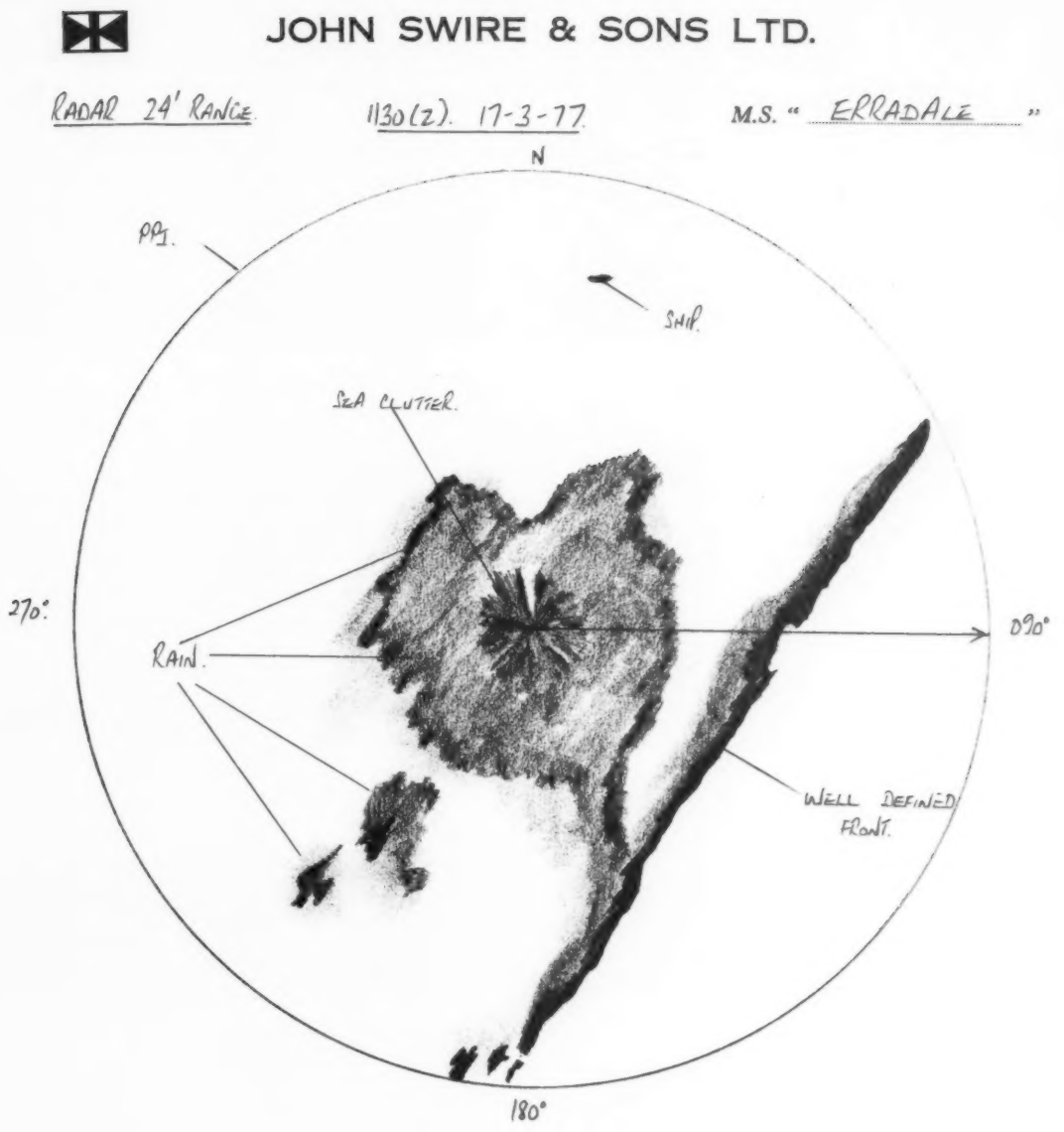


Figure 80.--The radar scope on the TILLIE LYKES as drawn by Third Officer Judson.

LOW had a pressure of 975 mb near 49°N, 180°. The A8ZH was 700 mi to the southwest with 50-kn winds and seas and swells of 26 ft. A ship about 300 mi west of the center had snow driven by 40-kn winds. The seas were 20 ft. The LOW crossed into the Bering Sea and paralleled the Aleutians. On the 25th, the U.S. Coast Guard cutter MELLON, south of Dutch Harbor, was swept by 45-kn winds and 10-ft seas on her port. On the 26th the LOW paralleled the southern Alaska coast and moved ashore near Yakutat on the 27th. At 0000 a ship near 54°N, 151°W, reported 33-ft seas. The identity and windspeed were not clear on the chart.

Tropical Cyclones, Western Pacific--Tropical storm Patsy, the first of the season, appeared as a tropical depression on the 23d near 3°N, 165°E. Her north-

westward course took her through the Caroline Islands (fig. 81). On the 28th she reached tropical storm strength just west of Ngatik Atoll. Patsy generated 50-kn winds for a short while on the 28th and early on the 29th. She passed about 120 mi northeast of Truk Island on the 30th, shortly before falling to tropical depression strength. The following day she dissipated.

Casualties--The 16,654-ton EASTERN ROSE and the 40,404-ton PETRA collided in a snowstorm on the 4th while off Cape Shio. The EASTERN ROSE sank about an hour later. The PETRA rescued 16 survivors from a rubber boat, 7 were rescued by freighters, and 2 were killed. The CALIFORNIAN was at Honolulu on the 15th with damage after being struck by a huge wave on the 13th. The drilling rig OCEAN SEVEN 1 was blown aground near Nasa Bay, Japan. The rig was listing about 10 degrees.

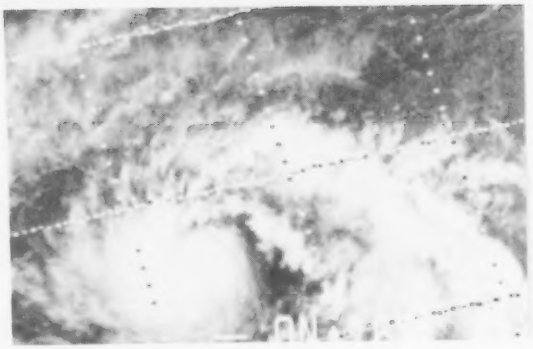


Figure 81.--Patsy develops very close to the Equator on the 26th.

ADDRESSES OF NATIONAL WEATHER SERVICE PORT METEOROLOGICAL OFFICES

NOAA National Weather Service Port Meteorological Offices have personnel who visit ships in port to check and calibrate barometers and other meteorological instruments. In addition, port meteorologists assist masters and mates with problems regarding weather observations, preparation of weather maps, and forecasts. Meteorological manuals, forms, and some instruments are also provided.

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Marine Weather Diary

NORTH ATLANTIC, JUNE

WEATHER over the North Atlantic is usually very pleasant in June. The number of active extratropical LOWs continues to decline, and storms are usually confined to the higher latitudes--centers north of 45°N over the western ocean and 55°N over the eastern ocean. The building Azores High averages near 1024 mb for the month and is centered over midocean near 33°N, 38°W. The Icelandic Low, oriented east-west, is quite diffuse with the lowest average pressure about 1010 mb, just off the coast of Labrador, near 58°N.

WINDS are controlled largely by the Azores High, with the transient LOWs causing the daily variations. Between 25° and 55°N, southwesterly winds predominate, except over the eastern ocean from the Bay of Biscay southeastward, where northerly winds prevail. South of 25° to about 5°N, the "northeast trades" are generally steady. North of 55°N, winds are mostly variable. On the Mediterranean, east to southeast winds are common over the western half, while northwest winds blow steadily over the eastern portion. Northerly winds are predominant off the Iberian Peninsula and northwest coast of Africa. Northwesterly winds prevail over the eastern Gulf of Mexico, while southeasterly winds are predominant over the southern North Atlantic between the Equator and 5°N. Windspeeds over most of the North Atlantic during June are force 3 to 4. Lighter force 2 to 3 winds are most common over the Mediterranean Sea, Davis Strait, Gulf of Mexico, Bay of Biscay and waters southwestward, and near the Equator. A band of force 4 to 6 extends northeastward from the vicinity of Bermuda toward Ireland.

GALES over the North Atlantic are infrequent during June. Only in the waters near southern Greenland and over northern portions of the Norwegian Sea does the probability of encountering gales exceed 10 percent.

EXTRATROPICAL CYCLONES are fewer in June than in May and not as intense. Cyclogenesis throughout the summer occurs principally in the area from the Carolinas, west of 65°W, to Hamilton Inlet, Labrador, west of 50°W; north of Scotland; northwest of Iceland; over the waters southwest of the British Isles; and over the Gulfs of Finland, Riga, and Bothnia. The major storm tracks during June extend from the Newfoundland area northeastward to the waters south of Iceland, and then east-northeastward across the Scandinavian Peninsula. Another primary track extends from Iowa across central Lake Michigan to southern Lake Huron and down the St. Lawrence River, where it joins a track that develops off Cape Cod.

TROPICAL CYCLONES. Tropical storms average about one every 2 yr. The preferred area of tropical cyclone formation is over the western Caribbean and the Gulf of Mexico. The 46-yr period, 1931-76, had 25 tropical storms, of which 11 reached hurricane strength.

SEA HEIGHTS of 12 ft or more occur between 5 and 10 percent of the time over a broad area that includes the Labrador Sea, around the southern Greenland coast into Denmark Strait, then south of Iceland to the Faeroe Islands and southward to off Ireland's west coast, then southwestward to about 500 mi off Cape Race, and northwestward to include again the Labrador Sea. Other small areas are located between Norway and the Shetland Islands, off the central Norwegian coast, and in the Gulf of Lions. Frequencies of 10 percent or more occur only over an elliptical area immediately south of Kap Farvel. A flat oval area of swell greater than 12 ft over 10 percent of the time is centered about 55°N, from south of Kap Farvel to Ireland. The oval changes from about 5° to 10° of latitude thick from west to east. An area of over 20 percent occurs about 200 mi off the coast of Colombia.

VISIBILITY. The frequency of fog approaches its maximum over the northern ocean. The Grand Banks is the foggiest region--visibility below 2 mi is reported on more than 30 percent of all observations. The percentage of this low visibility decreases to between 20 and 30 percent of the observations over the Davis Strait and the northern Labrador Sea, and over the waters east of Kap Brewster, Greenland. The latter area is usually ice-covered at this time of year. The fog is generally observed in warm, moist air brought by southerly winds into this area of cold ocean temperatures.

NORTH PACIFIC, JUNE

WEATHER. The summer regime is well established over the North Pacific in June. Vigorous extratropical storms are increasingly less frequent. The Subtropical High is centered near 36°N, 149°W, and has an average central pressure of about 1022 mb. The Aleutian Low, located north of the western Aleutian Islands, fills rapidly during June; by the end of the month, it has disappeared, leaving only a trough.

WINDS north of the trade wind belt are variable over the broad scale, ranging from northwesterly to northerly off the United States and Canadian coasts, to southerly east of Japan, to westerly over the Aleutians. Over the Gulf of Alaska, they are southerly to westerly. Northeast of Hawaii, the winds blow from the northeast. The speeds average force 3 to 4 north of 25°N. South of 25°N (30° east of 145°W) to the Equator, steady "northeast trades" dominate, with force 4 the most common speed. The southwest monsoon is established over the South China Sea. Southeasterlies prevail over the Philippine Sea, switching to southerly south of Japan and Korea.

GALES are rare in June. Only over a small area near 46°N, 145°W, does the chance of encountering gales exceed 5 percent.

EXTRATROPICAL CYCLONES. The most favorable area for cyclogenesis continues to be east of Honshu.

The primary storm tracks lead from here east-northeastward to the Gulf of Alaska. Another track approaches the Gulf of Alaska on a northeasterly course from midocean.

TROPICAL CYCLONES. The probability of tropical storm development continues to rise sharply in June, approaching the late summer and early fall maximum. On the average, three of these storms develop per year--one or two during this month in Asiatic waters, and one or two over the ocean area between 10° and 20°N, and the Mexican west coast and 120°W. About two out of three western North Pacific tropical storms go on to become typhoons. One out of three eastern North Pacific storms reach hurricane intensity.

SEA HEIGHTS of 12 ft or more have a frequency greater than 10 percent only in two small areas. One is centered south of the Alaska Peninsula near 48°N, and the other south of the western Aleutians near 46°N. Generally, sea conditions are improving as summer approaches. Areas of high swell are located in the northern Gulf of Alaska and Bering Sea, south of the ice edge.

VISIBILITY. The frequency of low visibility increases over most of the North Pacific. The waters east of the northern Kuril Islands are particularly foggy, with the visibility dropping below 2 mi in over 40 percent of the observations. From the outer boundaries of this area northward to Kamchatka, southward to the central Kurils, westward to the eastern Sea of Okhotsk, and eastward to 162°E, this percentage drops to 30 to 40 percent of all observations. The area of low visibility, which encompasses 20 to 30 percent of all observations, extends from the southern Sea of Okhotsk through the central Kurils, and then eastward through the North Pacific along the 40th parallel to 165°W. The line bordering the boundary of the area then bends westward to midocean near 47°N, 175°E, before curving northeastward through the central Aleutians to St. Lawrence Island in the Bering Sea.

NORTH ATLANTIC, JULY

WEATHER conditions are relatively settled during July as the Azores High, centered near 35°N, 44°W, builds to a seasonal maximum of about 1025 mb, and primary storm tracks are displaced north of 45°N. The Icelandic Low remains an ill-defined east-west trough with the lowest pressure, about 1009 mb, centered near Hudson Strait in eastern Canada.

WINDS over the middle and northern latitudes have southerly and westerly components. Northerly winds are common near the entrance to the Mediterranean, while over the Sea itself, northwesterly winds are steady. Winds from the northerly quarter are found over the North Sea, off the central Norwegian coast, and over the Davis Strait and the waters southwest of Iceland. The "northeast trades" blow between 10° and 25°N, while in the Gulf of Mexico, easterly winds are most frequent. Near the Equator, southeasterlies dominate the area between South America and Africa. Windspeeds average about force 3 to 4 over most of these areas except over the Mediterranean Sea, the Davis Strait, and the Gulf of Mexico, where force 2 to 3 winds are prevalent. The strongest winds, of which nearly two-fifths of all observations are force 5, are encountered over the waters of the southwestern Caribbean Sea.

GALES. The frequency of gales is at a minimum for the year. Only over the Norwegian Sea is the percentage frequency of gales 10 percent or higher.

EXTRATROPICAL CYCLONES. From June to July, a marked northward shift of cyclonic activity occurs over the North Atlantic. Areas of cyclogenesis are along the North American coast from the Carolinas to north of Newfoundland, in the Denmark Strait, southwest and north of the British Isles, in the Adriatic Sea, and over the Gulfs of Bothnia, Finland, and Riga. The primary cyclone tracks lead from the Hudson Bay region northeastward through the Davis Strait, from the Grand Banks and the Gulf of St. Lawrence toward Iceland, and from north of Scotland eastward across southern Scandinavia. Two secondary tracks cross the Great Lakes. One extends from the Great Plains across eastern Lake Superior toward Labrador, while the other cuts an east-northeasterly swath across Lakes Erie and Ontario, New York, and New England, before merging with the Carolina storm track over the Gulf of St. Lawrence.

TROPICAL CYCLONE activity is still limited. On an average, three storms will occur during a 4-yr period, and half will develop into hurricanes. July tropical cyclones usually originate over the Gulf of Mexico or just east of the Lesser Antilles. Those forming over the Gulf generally move northward across the Gulf Coast, while those born east of the Lesser Antilles may move westward across the Caribbean Sea, or northwestward toward the southeast coast of the United States, where they often recurve to the northeast. Sometimes these storms are bred north and east of the Bahama Islands during July.

SEA HEIGHTS of 12 ft or more are encountered with a frequency of 10 percent or more only in a small area immediately south of southern Greenland.

VISIBILITY. Like June, July is one of the foggiest months of the year over the western North Atlantic. Observations with visibility less than 2 mi average 10 percent or more northward of a line drawn from the waters between Cape Cod and Cape Sable northeastward to near 60°N, 30°W. From there, the 10-percent frequency line runs eastward, south of Iceland, to near the Faeroe Islands, and then southward, cutting across Scotland near the Firth of Forth. The line then extends northward along the Prime Meridian to about 63°N, where it heads northeastward to the coast of Norway. The 20-percent frequency line is a little less erratic. It extends from near Cod Island, Labrador, eastward to near 56°N, 47°W; it then extends southwestward across Newfoundland to the Grand Banks. From there, visibilities less than 2 mi occur 20 percent or more of the time west of a line drawn to the coastal waters of Greenland, near Kap Mosting, and then north of the same line extended to 74°N, 20°E. Enclosed within the area defined by Godthaab (Green-

land), Resolution Island, and Ivigtut (Greenland), observations with visibility less than 2 mi exceed 30 percent.

NORTH PACIFIC, JULY

WEATHER. The steady and rather settled summer weather conditions that commenced in June over the North Pacific become widespread and firmly established during July. The Aleutian Low has disappeared from the pressure chart of normals, and the Subtropical High, with a pressure of 1026 mb, has moved northward to near 38°N, 150°W.

WINDS. Because of the strong development and northward position of the Subtropical High, the "northeast trades" extend over a large portion of the ocean. They prevail over all but Asiatic waters south of 30°N. Over the eastern ocean, they extend northward to about 35°N. The southwest monsoon is well established in Asiatic waters, blowing most steadily over the South China Sea. The westerlies of the middle latitudes, because of the absence of the Aleutian Low, are less steady than during the colder months. Large southerly components are found over the western two-thirds of the ocean at these latitudes, while northerly components are the rule closer to the conterminous United States and are also observed out from the Gulf of Tehuantepec. Easterly winds prevail over the waters of the Gulf of Alaska. Windspeeds over the Pacific average slightly less than force 4.

GALES associated with extratropical cyclones are rare during July over almost all of the North Pacific, but a frequency greater than 5 percent does exist over a 2° square north of the central Aleutians.

EXTRATROPICAL CYCLONES. Cyclogenesis during the summer occurs in Asiatic waters from Taiwan northward to Sakhalin, and northeastward to the Near Islands. The greatest frequency is east of Honshu and Hokkaido. Two other areas are found near 47°N, from 155° to 175°W, and over the Gulf of Alaska. The primary storm tracks lead from Honshu northeastward to the Bering Sea, and from a point near 52°N, 157°W, to the Gulf of Alaska.

TROPICAL CYCLONES. Usually three or four tropical storms occur over the western North Pacific during July. Only one of these will not become a typhoon. These storms originate mostly over the ocean areas east of the Philippines. During their early stages, they generally move west-northwestward; after development, some may continue across the northern Philippine Islands into the South China Sea, while others curve northwestward toward Taiwan, the coast of mainland China, Korea, or Japan. Those reaching higher latitudes generally recurve toward the northeast under the influence of the upper westerlies.

Another area of tropical cyclone activity is over the waters off the west coast of Mexico. Around four tropical storms can be expected in July, with one reaching hurricane force. These storms are usually shorter lived, but can be dangerous to both marine and coastal interests. They normally move west-northwestward out to sea, but sometimes they pass inland over Baja California.

SEA HEIGHTS of 12 ft or more may be expected about 10 percent of the time in two small areas south of the Aleutians, near 48°N, 165°E, and near 49°N, 155°W. Areas of high swells are located in the Gulf of Alaska and Sea of Okhotsk.

VISIBILITY. Compared to other months of the year, the occurrence of low visibility over northern waters is most frequent during July. The visibility drops below 2 mi in over 40 percent of all observations over a circular area bordering the northern Kurils on the west and centered near 48°N, 158°E. The 30-percent frequency line is less circular, running from southwestern Kamchatka across the central Kurils to a point near 43°N, 160°E, and then northeastward to the Rat Islands, before swinging westward to Mys Shipunskiy. The 20-percent frequency line also crosses the central Kurils, but extends farther up the west coast of Kamchatka. This line then continues southeastward from the Kurils reaching south of 40°N, between 160°E and the dateline, before moving east-northeastward to a point near 48°N, 145°W, and then north-northwestward to Afognak Island. The entire Bering Sea is enclosed within this 20-percent frequency line, with the exception of the waters northeast of St. Lawrence Island, and the waters north of a line drawn from Mys Ozernoy to Mys Navarin. The 10-percent frequency line is very similar to the 20-percent one. It stretches from the northern Sea of Okhotsk southward to the southern Kurils; it then continues southeastward to a point near 34°N, 170°E, before shooting east-northeastward to about 40°N, 140°W, and then north-northwestward to the Gulf of Alaska.

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